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9

Geological Survey of New Zealand.

JAMES HECTOR, M.D., F.R.S.,
DIRECTOR.

REPORTS
OF
GEOLOGICAL EXPLORATIONS
DURING 1873-4.

WITH MAPS AND SECTIONS.

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ERRATA.

Page VI., line 29—For *Waikara* read *Waikawa.*
Page XVI., line 1—For *Kahihu* read *Kahiku.*
Page 3, line 2 from bottom—For *quartz, porphyry* read *quartz-porphyry.*
Page 6, line 11—For *spinigera* read *spirigera.*
Page 14, line 13—For *banks* read *bands.*
Page 17, line 28—For *Sumner* read *Somers.*
Page 18, line 36—For *Trellissic* read *Trelissic.*
Page 32, line 28—For *Clerence* read *Clarence.*
Page 63, line 4—For *Pholdomya* read *Pholadomya.*
Page 65, line 19—For *These shells do* read *This shell does.*
Page 66, line 18—For *it several* read *it at several.*
Page 69, line 33—For *Rynconella* read *Rhynchonella.*
Page 74, line 14—For *Enchinodermata* read *Echinodermata.*
Page 76, line 3—For *Cockbulla* read *Kokopua.*
Page 81, line 24—For *than here* read *as here.*
Page 96, line 23—For *12 inches* read *12 feet.*
Page 100, line 23—For *confines* read *confine.*
" line 34—For *circular* read *acicular.*
Page 101, line 16—For *Waldehemias* read *Waldheimias.*
Page 102, line 4—For *coating* read *coatings.*
Page 113, line 8—For *White Point* read *White Rock Point.*
Page 125, line 9—For *clearing* read *clearly.*
Page 129, line 28—
Page 130, lines 1 and 7—
Page 139, line 9—
Page 157, lines 21, 23 and 33—
Page 158, line 30—
Page 160, line 8—
For *zitelli* read *zittelli.*
Page 154, line 30—For *to be alternate* read *to alternate.*
Page 157, line 29—
Page 158, line 17—
For *Planorbus* read *Planorbis.*
Page 158, line 24—For *Mythius* read *Mytilus.*

PROGRESS REPORTS, 1873-74,

DURING the season's work to which the following reports refer the attention of the officers of the Geological Survey has been chiefly directed to the examination of those districts of the colony, the structure of which either directly or indirectly bears on the stratigraphical position and extent of our coal bearing formations.

WEST COAST OF SOUTH ISLAND.

In the early part of the year I re-visited all the coal fields on the West Coast, from Preservation Inlet to Cape Farewell, devoting several months to the most important areas in the western district of Nelson Province, with the view of promoting the establishment of mines.

Collingwood.—The chief work at this place during the past year has been the extension of the tunnel for the purpose of exploring the coal measures, which was recommended in last year's report.

The tunnel is now in about 390 feet, with favourable indications; and there still remains about 300 feet more before the main coal seam can be cut, which is expected to be accomplished about the end of this year. The importance of carrying out this work, with the view of exploring coal measures that extend over a very large area, as shown on the attached map of the district, and containing a very valuable description of coal, and in the vicinity of a good shipping place for vessels of the largest size, has already been urged in a former report; and since the discovery of ironstone bands along with the coal, under circumstances that favour their being economically worked, there is still further reason for the expenditure in this district.

Mount Rochfort.—The coal seam at the Ngakawau River has been traced on to the high level plateau, and outcrops found at various points, so as to indicate its extension over a very large area; one block, containing at least 7,000,000 tons, being proved by the natural sections observed in the gullies. The main seam, which has a greatest thickness of 25 feet, is a trough shaped deposit, extending in a north and south direction for many miles, with a lateral extent of about one mile and a half, but it thins towards the margin to three feet. This trough of coal is broken by transverse faults, which reduce it from an average altitude of 2,00 feet on the plateau to the sea level at Ngakawau Mine.

As the coal is all above the water level, a very large proportion of i can be profitably extracted.

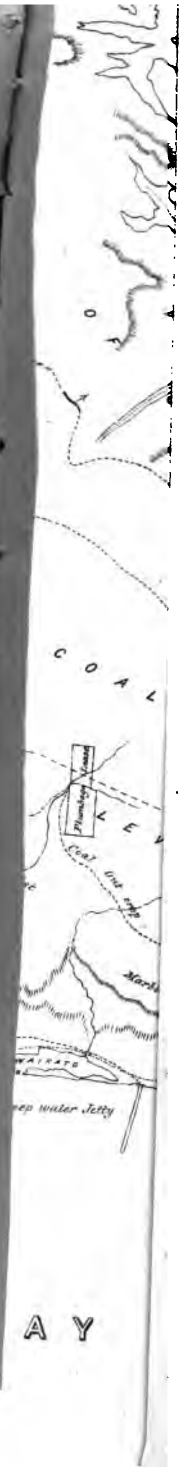
The discovery of coal in the bed of the Waimangaroa stream, nea the level of the sea, raised an expectation that the seam described in former report as occurring on the seaward face of Mount Rochfort might be found under circumstances favourable for its being worked.

A drive put into the spur for 130 feet, with the view of cutting th seam, has not however resulted in the discovery of valuable coal; but recommend that further explorations should be made either by continuing the drive already commenced, or by excavating in a fresh locality.

Grey River.—No change has been experienced in the character of the Brunner Mine; the rumour that was circulated to the effect that the fault had changed its direction, and that the extent of coal available was thereby diminished, being without foundation, as no fresh levels have been driven on the fault, nor have the workings been extended in that direction during the past year. Several areas of coal that can be worked by shafts have been marked out on the south side of the river, as shown in the attached plan, in that portion of the reserve leased to the Greymouth Coal Company; and, though no active operations have been commenced, there is every reason to expect that by the time the railway to that place is completed, a sufficient supply of coal will be available to keep it fully employed.

The detailed reports of this work have already appeared in print (Parliamentary Papers, 1873, E. 10), and as they have only an indirect bearing on the descriptive geology of the country, it is unnecessary to refer further to them here than to state that in all cases on the West Coast the sequence of the coal formation and overlying beds is the following:—

1. Calcareous sands and glauconitic limestone.
2. Black or grey marls.
3. Dark greensands.
4. Brown ferruginous sandstone.
5. Pitch coal.
6. Conglomerates and quartzose sandstone, with bituminous coal.

O
A
C O A L
L E V
Plumbago Mines
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ep water Jetty
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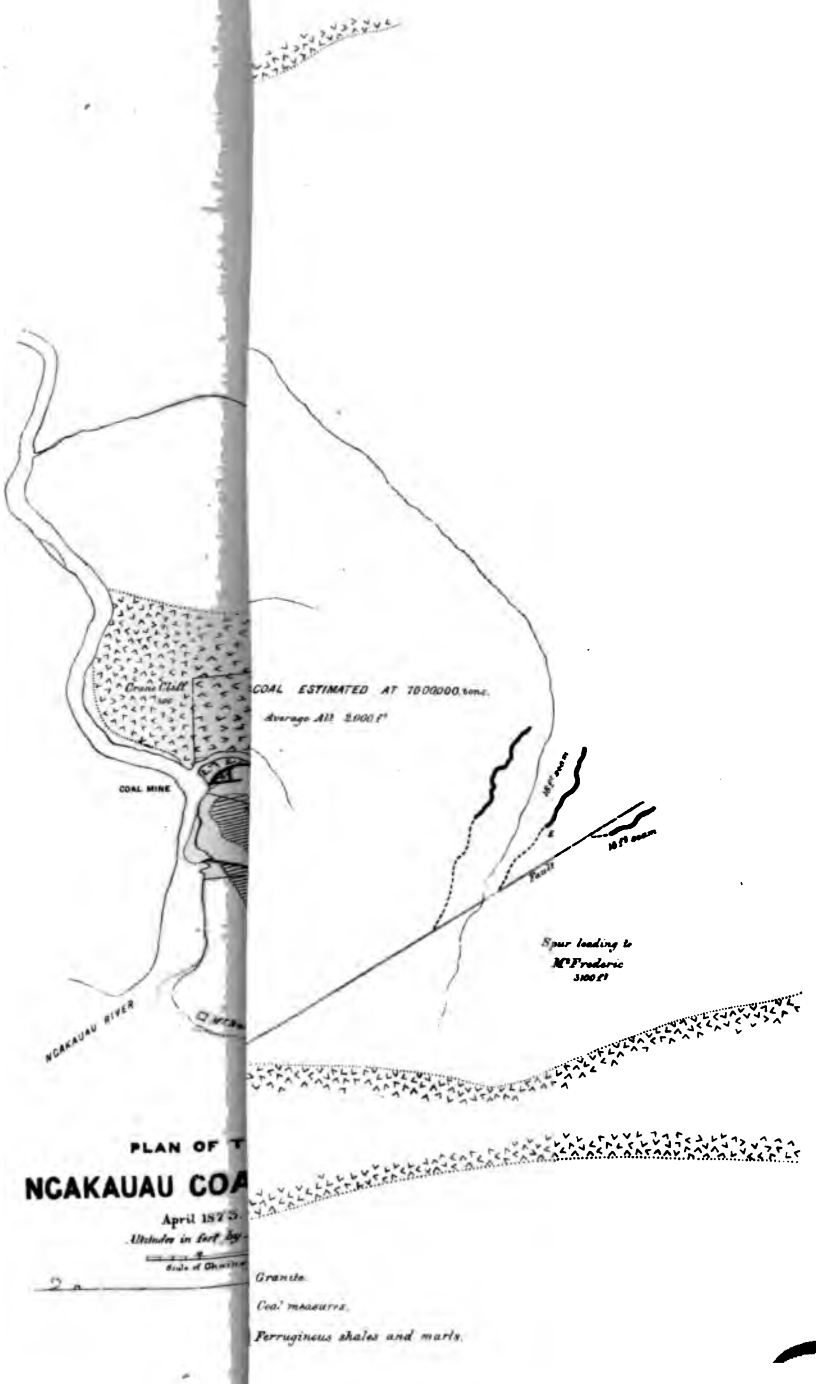Crane Cliff
300
COAL ESTIMATED AT 7000000 tons.
Average Alt 2000 ft
COAL MINE
18 ft seam
16 ft seam
Fault
Spur leading to
Mt Frederic
3100 ft
NCAKAUAU RIVER
PLAN OF T
NCAKAUAU COA
April 1875.
Altitudes in feet by
Scale of Chains
Granite.
Coal measures.
Ferruginous shales and marls.

171.

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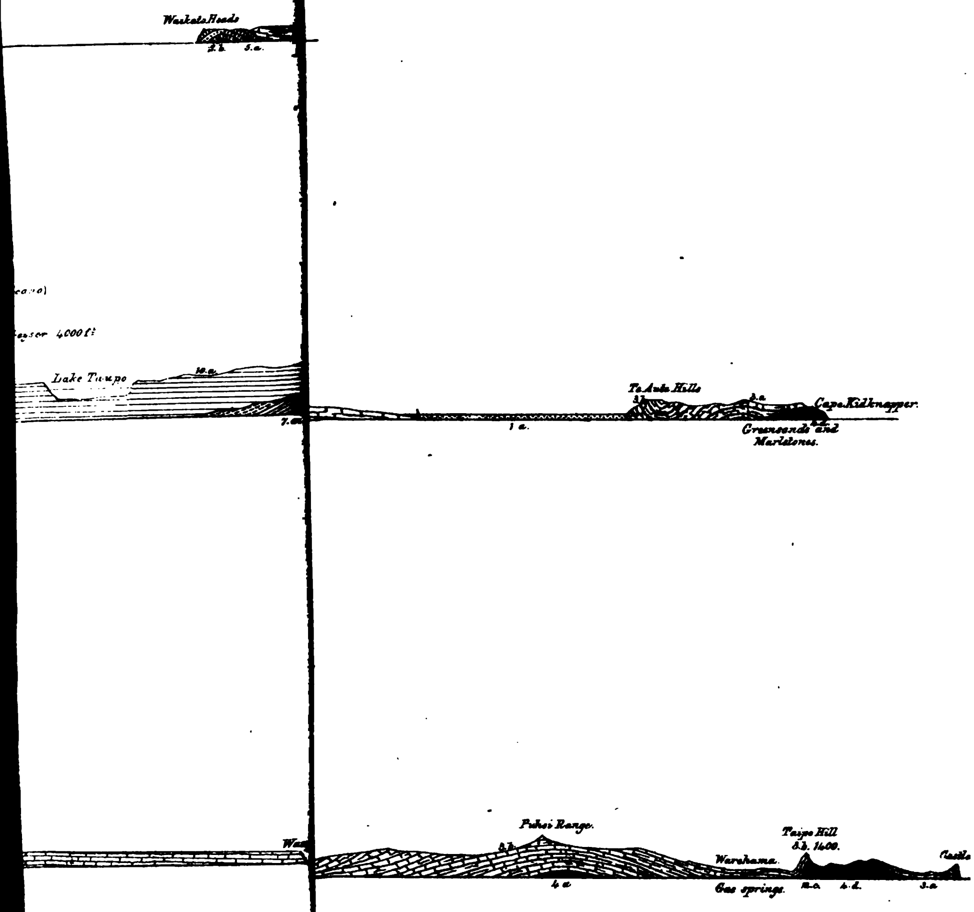
NORTH I



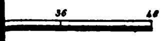
BY Dr HECTOR GOVt GEOLOGIST. N.Z. FEBY 1871

FORMATIONS.

læozoic.—*a.* Te Anau Series. *b.* Maitai
d. Mt. Arthur Series.

liated Metamorphic.—*a.* Arenaceo
Schist. *c.* Mica Schist. *d.* Quartz Sc
f. Gniessic Schist.

ystalline.—*a.* Newer Gniess. *b.* Old
Gniess. *d.* Gniess-granite.



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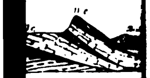

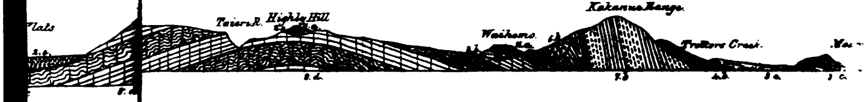

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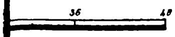
FOR

Palæozoic
d. M



Foliated
Schi
f. G

Crystalli
Gnie

7. Coarse breccia, or Morainic deposits, indicating the denudation of Alpine regions.

These strata form a distinct group, both on stratigraphical and palæontological grounds, which, however, admits of many minor sub-divisions.

It has a total thickness of several thousand feet, the lower members especially being frequently expanded to an immense degree. Originally it was spread over a vast area of country, and now remains as outlying patches in all situations from near the sea level along the West Coast, in the interior valley of the Buller River, and to the summit of the intervening mountain ranges at an altitude of 5,000 feet.

GEOLOGICAL MAP AND SECTIONS.

In February, 1873, a geological map was prepared on the scale of 12 miles to an inch, and forwarded to the Vienna Exhibition for publication in Europe on a reduced scale.

The scheme of classification adopted for the geological formations in the map may be gathered by reference to the accompanying Sections of the Islands, taken across country on various lines on which the relative positions of the formations are most clearly defined in relation to the surface features.

CLENT HILLS AND MOUNT SOMERS.

In the beginning of the year Dr. Haast was employed to report on the strata of the Clent Hills District in Canterbury, chiefly with the view of discovering what relation existed between the plant beds of the Clent Hills and the Mount Potts fossiliferous beds.

In his report he describes at length the general structure of the Southern Alps, quoting from his previous reports to show that they consist of successive anticlinal and synclinal arches of sandy slate, breccias, and conglomerates, with a prevailing N.E. strike. Bands of diabase or contemporaneous ash beds and calcareous strata also occur.

Fossils have only been discovered in these older beds in the Upper Rangitata and at the Clent Hills, those from the former locality being pronounced by Professor McCoy to be Upper Devonian; those from the latter, which are all plant remains, to be Jurassic; but Dr. Haast considers these also to be Palæozoic, on stratigraphical grounds.

The Diabase Rocks are next in age, and occur in patches, associated with limestone, cherts and semi-metamorphic forms of slates and sandstones.

The formations which succeed the foregoing comprise a great variety of sandstones, shales, conglomerates and slates, much indurated, and presenting a great variety of strike, but no faults.

Resting unconformably on the above are Igneous rocks of two groups :—

a. Basic amygdaloid, traversed by dykes of Melaphyre.

b. Quartzose porphyritic trachyte and contemporaneous Tufas.

This Acidic Group being the most recent, and pitch stones marking the line of junction between the two.

Flanking these rocks are thick deposits of conglomerate, formed of fragments of Porphyry and Tufaceous shales, with Dicotyledonous and Coniferous plant remains.

Next in ascending order, but with passage beds, comes the brown coal formation, the seams being at times altered by Igneous rocks of subsequent date.

The shales accompanying the brown coal pass upwards into sands, sometimes glauconitic, with which a highly fossiliferous bed occurs, containing a large black oyster and many other shells, with occasionally rolled fragments of Saurian bones and fish teeth.

A formation of quartzose sands, capped by Dolerite sheets and Tufaceous clays, completes the series in ascending order, capped by the alluvial deposits.

The section is stated to be generally the same as that at the Waipara, with the exception of the Igneous rocks, which are there absent.

With reference to the foregoing conclusions, I have to state that the Pecopteris, Tœniopteris, and Camptopteris, mentioned by Dr. Haast, are all quite different in appearance from the Australian species, but the same species have been obtained in the Waikara beds in Otago, which are certainly not Palæozoic, but of the same age as the Mataura series.

The negative evidence adduced cannot be considered of much value, and it is advisable to reserve opinions on the question of the relations which exist between these plant beds of the Clent Hills and the Mount Potts' Spirifer beds, until more direct evidence can be obtained than we are at present in the possession of.

NORTH-EAST PORTION OF SOUTH ISLAND.

In December and January the Assistant Geologist, Capt. Hutton, made a rapid examination of the N.E. district of the South Island, and in his report proposes several important modifications of the geological classification previously assigned to New Zealand. During this period a tract of mountainous country, 11,000 square miles in extent, was examined, and the following nomenclature was adopted for the various formations :—

1. Palæozoic.—
   - *(a.) Tuamarina Formation.*—Consisting of phyllites, quartzites, chlorite schists, sandstones (with *Othoceras* and *Phragmoceras* ?), and conglomerates.
   - *(b.) Kaikoura Formation.*—Consisting of grey and dark green sandstones, with numerous quartz veins, fine argillaceous sandstones, conglomerate, grey argillite, clay slate, and purple jasperoid slates, passing into quartz rock. The only fossils obtained are Annelide markings, and probably also a coral from Harataonga Bay, in the North Island.
2. Mesozoic.—
   - *(a.) Wairoa Formation (Upper Trias).*—Occurring only in the neighbourhood of Nelson, and forming the Richmond Hill, extending up to the Wairoa Gorge.
   - *(b.) Maitai Formation (Lower Jurassic).*—Consisting of dark grey and green sandstones, green and dark blue slates, greenstone tuff, and conglomerates, often containing large quantities of pebbles of jasper.
   - *(c.) Putataka Formation (Middle Jurassic).*—Consisting of green sandstones and shaly slates, no fossils, except obscure plant remains, being found in this district. Thin unworkable coal seams occur associated with these rocks.
   - *(d.) Waipara Formation (Upper Cretaceous).*—Which is subdivided thus :—
     - *(a.) Ngarara Group.*—Consisting of grey shales and grey or green sandstones, passing in their upper beds into a calcareous sandstone in the more northerly part of the district. Coal occurs, associated with these beds, in the Malvern Hills, and Saurian bones have been obtained from them, in addition to a large number of other fossils.
     - *(b.) Amuri Limestone Group.*—Consisting of a white or pale grey argillaceous limestone, always in thin beds,

and often much broken up. It forms the uppermost part of the Mesozoic strata generally.

3. TERTIARY.—

(*a.*) *Oamaru Formation.*—Which is not considered to be of greater age than Upper Eocene, is subdivided into :—

(I.) *Ototara Group.*—Consisting of a calcareous sandstone of varying texture from coarse to fine.

(II.) *Trelissic Group.*—Being composed in their lower beds of blue sandy clay and soft yellow, grey or green sandstone, generally with limestone or calcareous sandstone at the top. Basaltic tufas and lava streams are associated with these beds.

(*b.*) *Ahuriri Formation (Lower Miocene).*—Consists of shales and green sandstones, passing up into shelly limestones.

(*c.*) *Pareora Formation (Upper Miocene).*—Consists of blue sandy clay and soft grey or yellow sandstone, passing upwards in places into a coral or shelly limestone. These beds are divided from the last on palæontological grounds. This formation has been sub-divided palæontologically into the Kanieri and Awatere Groups, volcanic rocks occurring, associated with the latter.

Captain Hutton considers that between the Tuamarina and Kaikoura formations no break occurs.

The next three formations met with are described in ascending order, and then a stratigraphical break is recorded between the Putataka formation and the Waipara beds.

The tertiary series of Captain Hutton, comprising his Oamaru formation, he describes as resting unconformably on the Amuri limestone, and refuses to give it any greater age than Upper Eocene, on the ground that the Mesozoic forms found in these rocks only prove that the fauna of New Zealand had then, as now, a more ancient facies than the fauna of Europe.

Captain Hutton considers that the Canterbury Plains have, since the commencement of the Pliestocene period, been raised 1,700 feet, on the grounds that these plains are evidently due to marine action, and that in the terraces of the Motanau and Conway we have proof that in quite recent times the sea stood at least 300 feet higher than it does now.

EAST COAST OF WELLINGTON.

During the month of October I examined the eastern district of the Wellington Province inland from Castle Point, and found that along the seacoast middle secondary rocks are exposed. These consist of sandstones and marly shales, containing Inoceramus and other fossils, by which I was able to refer them to the Amuri Group.

In passing inland these are succeeded by greensands, chalk marls, and calcareous sandstones, with Pecten pleuronectes, indicating the horizon of the Aotea Group, which are again overlaid unconformably by the Hawke's Bay series, forming the Taipos, and on them a succession of clay marls and limestone, belonging to the Upper Tertiary series, are found in the Puketoi Ranges.

This district possesses some interest from the numerous gas escapes which are found along a line eastward of the Taipos, indicating the presence in the underlying secondary rocks of reservoirs of inflammable hydro-carbons.

MARLBOROUGH AND AMURI DISTRICTS.

The remainder of the year I devoted to the examination of some of the sections relied on by Captain Hutton for the changes he had made of the geological classification, and arrived at the following conclusions:—

1. A great part of his " Tuamarina Formation" consists of foliated metamorphic rocks, similar in character and stratigraphical position to the auriferous schists of Eastern Otago. The forms quoted by Captain Hutton are very obscure, but I found were, without doubt, derived from an outlier of the *Leda* marls which occupy the valley behind Picton, and from which there are specimens of Dentalium and Pecten pleuronectes in the Museum, collected by myself in 1864.

2. The relative positions of the Maitai and Wairoa formations must be reversed, as the section up the gorge of the Wairoa River shows the latter formation with its characteristic fossils (Monotis salinaria and Mytilus problematicus) to rest unconformably on the Maitai formation, which is in part the same thing as Captain Hutton's Kaikoura formation; the upper portion, which is characterised by the great development of tufaceous sandstones, greenstone slates, and breccias, with associated Diorites, Syenites and Serpentines, being the representatives of the Te Anau series of the Geological Map.

3. Some areas referred to the Wairoa series, such, for instance, as that lying to the east of the Hanmer Plains, and north to the Amuri

Bluff, should, I consider, be referred to the horizon of the Putataka formation in the North Island, although no evidence from fossils has been obtained.

4. The Putataka formation, with canaliculate Belemnites and Ammonites, is distinct from the Mataura series, which is overlying these beds both in the North Island and also in the S.E. of Otago, being characterised by the presence of fossil plants, such as Tœniopteris lata, Pecopteris hochstetteri, and Camptopteris, the species being in some cases identical with those obtained in the Rajmahal Hill beds in India. The green sandstones with fossil plants in the Malvern Hills, and probably the lower beds at the Amuri Bluff and Mandamus, are the representatives of the Mataura series in the district.

5. After a careful examination of the section at Kaikora Peninsula and Amuri Bluff, and a re-examination of those at the Weka Pass, Waipara and Trelissic, I was unable to satisfy myself of any stratigraphical break between the Amuri limestone and the overlying grey marls, which latter Captain Hutton refers to his Pareora formation, but which I am forced to consider as only the upper part of the Amuri formation; the lower part of which, or Ototara sandstone proper, being separate from the glauconitic or fucoidal limestone, not by a denuded surface, but only by a layer of greensand nodules, which is not everywhere found, and is clearly of a concretionary nature, due to the presence of organic matter.

The reported occurrence at Flaxbourne of a yellow sandstone not elsewhere found, overlying the Amuri limestone, and therefore forming a representative of the Ototara formation, as shown in Captain Hutton's Section VIII., could not be established, as the sandstone in question is really beneath the limestone, and intervenes between it and a great formation of volcanic breccia, or agglomerate, on which the Amuri Group rests.

The following section of the strata exposed in the Amuri Bluff indicates the grouping I was forced to adopt for the upper secondary strata, represented by Capt. Hutton's Waipara formation (Ngarara and Amuri limestone groups) and part of his Oamaru formation, which will have to be broken up:—

CHALK GROUP.

(a.) Grey Marls (700 feet).—Greenish sandy and argillaceous marls, with hard and soft layers, Pecten zittelli, *Leda*,

Waldheimia, Scalaria, Cidarites, and bone fragments. These marls strike N. 40° E., with an increasing dip from 15° to 40° towards the base, where they gradually pass into greensands or yellow calcareous sandstone speckled with glauconite.

(*b.*) *Fucoidal Limestone (50 feet).*—An indurated calcareous sandstone, generally separated from *a.* by a thin layer of brecciated fragments of calcareous greensands, but frequently the greensand is inter-laminated, and fills the fucoid casts. The character of this junction is constant over a large area—from the Weka Pass to the Kaikoura—but at the latter place a corrugated concretionary disturbance of the calcareous beds has given rise to an apparent unconformity.—*Fish teeth and fucoids.*

(*c.*) *Flaggy Limestone (30 feet).*—Yellowish white, smooth-grained limestone, like indurated chalk, in thin layers. Pentacrinus, Pecten (fragments like Pecten hochstetteri) Inoceramus, in large fragments.

(*d.*) *Cherty Limestone (300 feet).*—Chalk, with flints. At Kaikoura the flints are more abundant, and are sometimes quite black.

(*e.*) *Grey Limestone (100 feet).*—A gritty, sub-crystalline limestone, weathering white. Worm casts and Pecten.

(*f.*) *Chalk Marls (300 feet).*—With hard indurated bands, and layers of greensand.

GREENSAND GROUP.

The strike changes in this group to N. 20° E., the dip being 30° E.S.E.

(*g.*) *Teredo Limestone (20 feet).*—Dark grey, sub-crystalline ferruginous limestone, weathers red, almost entirely composed of Teredo casts. Contains Trigonia alæformis var. and Pentacrinus.

(*h.*) *Greensand (20 feet).*—Incoherent, rather coarse grained, clear sands, of bright colours, generally green.

(*i.*) *Concretionary Greensand (300 feet).*—Calcareous green or grey sandstone, with large calcareous concretions, irregularly dispersed. Cucullæa (alta ?), Dentalium (like D. irregularis, but with large and small ridges alternating), Tellina scitulina, *Leda*, Scaphites, or Hamites, Ammonites (like A.

daintreei, but still more compressed), Belemnites lindsayi (n. sp., also found over the brown coal at Green Island, near Dunedin), Inoceramus (large fragments): Plesiosaurus australis was obtained from this stratum.

(k.) Boulder Sands (100 feet).—Dark grey laminated micaceous sands, with large spheroidal calcareous concretions, containing Mauisaurus haastii, Plesiosaurus traversii, P. hoodii, Polycotylus tenuis, Leiodon haumuriensis, and Taniwhasaurus oweni; also Aporrhais ornata, and Ostrea.

(l.) Gypseous, or Sulphur Sands (400 feet).—Dark grey and brown false bedded sands, coarse and fine in grain, the upper part being greensand. No fossils, but contains pyrites and gypsum, with coaly streaks and silicified wood. The weathered surface is often covered with a sulphur yellow efflorescence.

AMURI GROUP.

Strike nearly north and south.

(m.) Black Grit (20 feet).—Fine grained grit, of small waterworn pebbles, of green and white quartz, and a small quantity of titaniferous iron, in a grey calcareous matrix. Fossils abundant, but all rolled. Belemnites lindsayi, Pecten obovatus var., Radula, Plagiostoma, Inoceramus cuvieri, Trigonia sulcata, Mytilus. Fragments of bone and teeth, chiefly of fishes, but also Saurians. Polycotylus, Plesiosaurus.

(n.) Grey Sandstone (130 feet).—Compact calcareous sandstone, formed in parts almost entirely of shells. Panopæa plicata, Trigonia sulcata, Eriphylla (Dosinia) haumura, Axinæa (Pectunculus) cuneiforme, A. cardioides, Inoceramus multiplicatus, I. mytiloides, I. haastii, I. simplex, Aucella plicata, Radula, Alaria, Turbo, Pleurotomaria, Neptunæa, Ostrea, Crenella, Belemnites dilatatus and several other species. Fragments of bone; teeth, and scales of fish.

(o.) Calcareous Conglomerate (70 feet).—Light grey calcareous sandstone, with pebbles interspersed, chiefly of black siliceous sandstone and layers of fossils, principally Belemnites and fish teeth.

After withdrawing from Captain Hutton's Oamaru formation, the localities where the strata should, I consider, be referred to the Chalk marl and Ototara (or Grey marl) series, the grouping of the tertiary strata will become more simple, and from stratigraphical evidence will probably merge into two formations of Upper Eocene and Miocene age, but the further subdivisions of the tertiary formation must be postponed until more perfect collections of fossils have been obtained. I may state that the nomenclature proposed by Captain Hutton may be misleading, as at present known there is nothing very characteristic about most of the proposed formations, and in the case of the Pareora formation only one fossil has been determined from the locality, and the corelation of other beds throughout the Colony with this formation is unsatisfactory.

S.E. District of Otago.

From September to November Mr. McKay made collections from the S.E. district of the Province of Otago. The principal results obtained by this trip, apart from the acquisition of an extensive and most valuable collection of fossils, is the proof that Belemnites Lindsayi* is found *in situ* in the beds overlying the coal, having lived and died during the deposition of these beds, and not been introduced into them with rolled boulders of some older formation. It occurs between the Coal Grits and overlying green-sands.

The other fossils collected at Green Island contain decidedly cretaceous forms, and the beds immediately underlying the white calcareous sandstone, at Waihola Gorge, yielded a collection, in which some affinity can be traced, both to the Weka Pass stone and also to the Cobden limestone.

The junction between the Putataka and Mataura series, and the next beds below them, has not been shown in a satisfactory manner, but there is little doubt that the Nugget beds are overlaid by them uncomformably.

The lower beds of this series consist of alternations of coarse sandstones and dark shales, in which the remains of a land flora and Marine fauna alternate. The highest beds appear to be exposed in False Island as a conglomerate, and seams of coal are reported to occur in these beds, but none of a workable thickness have up to the present time been found.

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* The examination of the suit of specimens obtained shows that this species is the exfoliated core of a true Belemnite (allied to Belemnites dilatatus), being a form that would formerly have been placed in the Genus *Acanthocomax* of Miller.

The Kahihu Series or Nugget Point Beds form the Kahihu Range, and its south-easterly continuation to Nugget Point, and between the Popotuna Gorge and Nugget Point are richly fossiliferous. Collections were made at several points.

No junction was observed between these beds and the schistose rocks, upon which they, in all probability, lie.

WEST COAST DISTRICT.

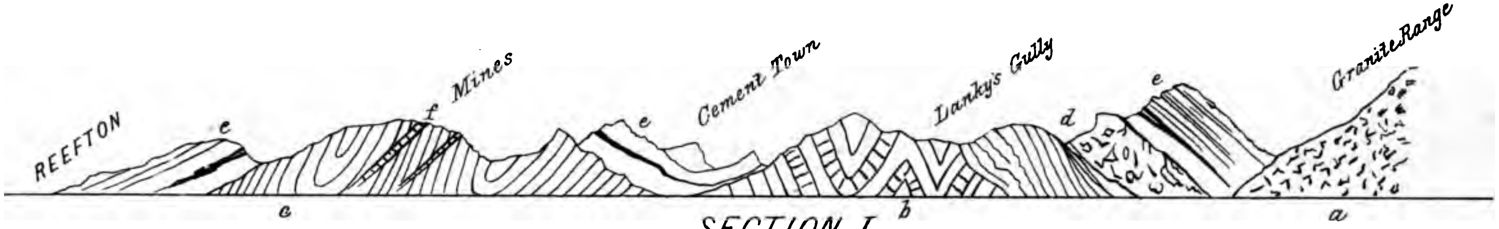
During January and February, 1874, I resumed the examination of the West Coast District, to which I crossed from the Amuri District by the Hurunui Pass. On this expedition Mr. McKay, whose full notes are appended, was engaged to assist in collecting fossils, and in the Greymouth District large collections were made, showing that between the tertiary beds of New River and the Cobden limestone a highly foraminiferous limestone intervenes, to which the name of "The Nummulitic Limestone" has been applied, and between which and the Cobden limestone an unconformity has been shown to exist in the New River District, although this unconformity is not very clear at Greymouth.

Collections were made at the Ten-mile Creek, the Brunner Mine, and at the Nine-mile Bluff, from beds which immediately overlie the coal, the similarity between these fossils and those obtained from the green-sands overlying the coal on the East Coast of the South Island, and also in the North Island, being remarkable.

In the Reefton District large collections were made from the cherts and limestone of Devonian age. The junction between these Devonian beds and the auriferous slate, as also between these and the granites, is often obscured by the coal measures, but the relations between these beds is in the manner shown in Section No. 1 :—

a. Granite.
b. Devonian cherts and limestones (Spirifer and Madrepore beds).
c. Auriferous slates.
d. Breccia.
e. Coal and quartz cements.
f. Auriferous reefs.

Heavy angular conglomerates, similar to those which occur at the base of the coal series at Greymouth, occur along the north branch of the Inangahua River, and between there and Boatman's Creek, being developed to an enormous extent in this locality. They are composed of huge angular blocks of granite of 10 feet or 12 feet in diameter, intermixed with smaller, but for the most part angular material.



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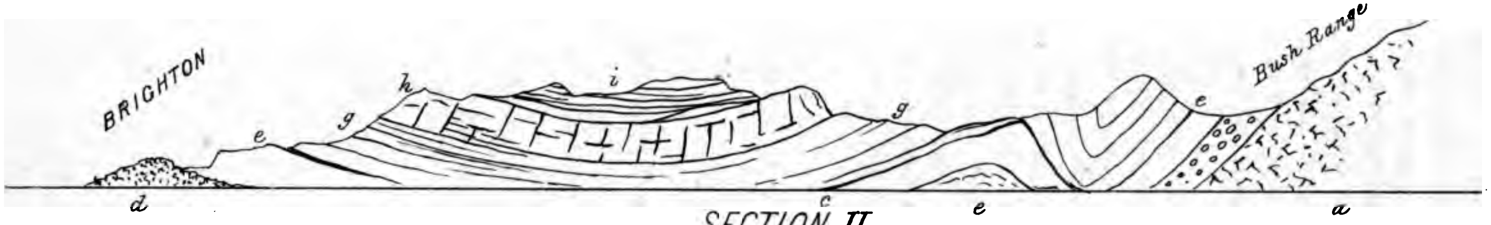

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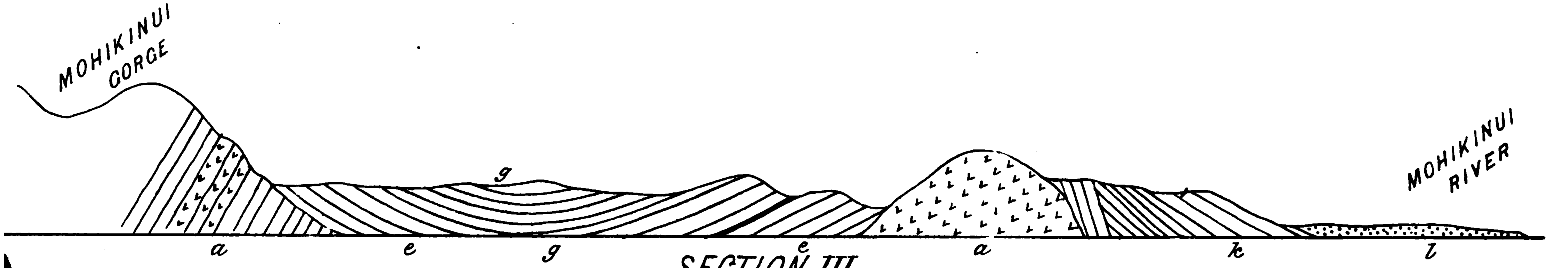


SECTION III.

A collection was made from the coal beds at the junction of the Inangahua and Buller Rivers, which is of interest, inasmuch as it shows that a limestone, very rich in foraminiferæ, occurs, closely overlying the coal in this locality,—the forms from this limestone differing, however, from those found in the limestone above the chalk beds of Cobden.

The Breccia beds at Hawke's Crag, on the Buller River, appear to be the lower part of the great Granite Breccia at the base of the coal, and which beds are seen with their usual characters a little further down the river.

Between Cape Foulwind and Brighton the concretionary limestone, with foraminiferæ mentioned as occurring in the middle Buller, is considerably developed, the higher limestone not being seen until the neighborhood of Charleston is reached. Fossils were largely collected in the neighborhood of Brighton, both from the bed directly overlying the coal, and also from a higher horizon.

In the low country between the coast line and the granite range, the limestone of the Fox River is overlaid by tertiary beds, rich in fossils, beyond which the coal beds rise and flank the granite, usually standing at high angles, as shown in Section No. 2.

a. Granite.
d. Breccia.
e. Coal and quartz cements.
g. Brown sandstones.
h. Limestones.
i. (Conus beds)?

In the Mokihinui District collections were made from the black marls immediately overlying the coal sandstones, the only remarkable fossil obtained being Pecten zittelli, this being the lowest horizon from which this form has been obtained.

Collections were also made in Page Creek from tertiary beds, rich in fossils, which flank the east side of the granite range between the Mokihinui and Ngakawau Rivers, and Section No. 3 illustrates the position of the beds here:—

a. Granite.
e. Coal and quartz cements.
g. Black marls.
k. Conus beds.
l. Alluvium.

East Cape District.—During March and April, 1874, I examined the beds between Poverty Bay and the East Cape, on account of the discoveries of petroleum wells that had been made in that district, taking Mr. McKay with me to make collections and follow up sections where necessary. It has been deemed advisable to publish his notes while engaged upon this work *in extenso;* and the following sketch of the formations, together with the map and sections appended, will serve to illustrate the geology of the district. The numbers refer to the subdivisions of the strata shown in the sections :—

I.—POST TERTIARY.

Gisborne Series (No. 1).—

a. Sandhills and raised beach, elevated 16 feet above high-water mark. The shell bank on which the town of Gisborne is situated, belongs to this part of the formation, and contains many species of shells, all of which are still existing on the coast in the vicinity.

b. Deposit of indurated sand, with impressions of moa footsteps exposed underneath the raised beach at the mouth of the Turanganui. The sand deposit passes into a blue silt, and forms the surface of the interior portion of the Poverty Bay flats, extending to the base of the spurs, on which it reaches a considerable elevation. Along the foot of the hills it rests on a thick deposit of impure lignite, which is known as Bryant's coal.

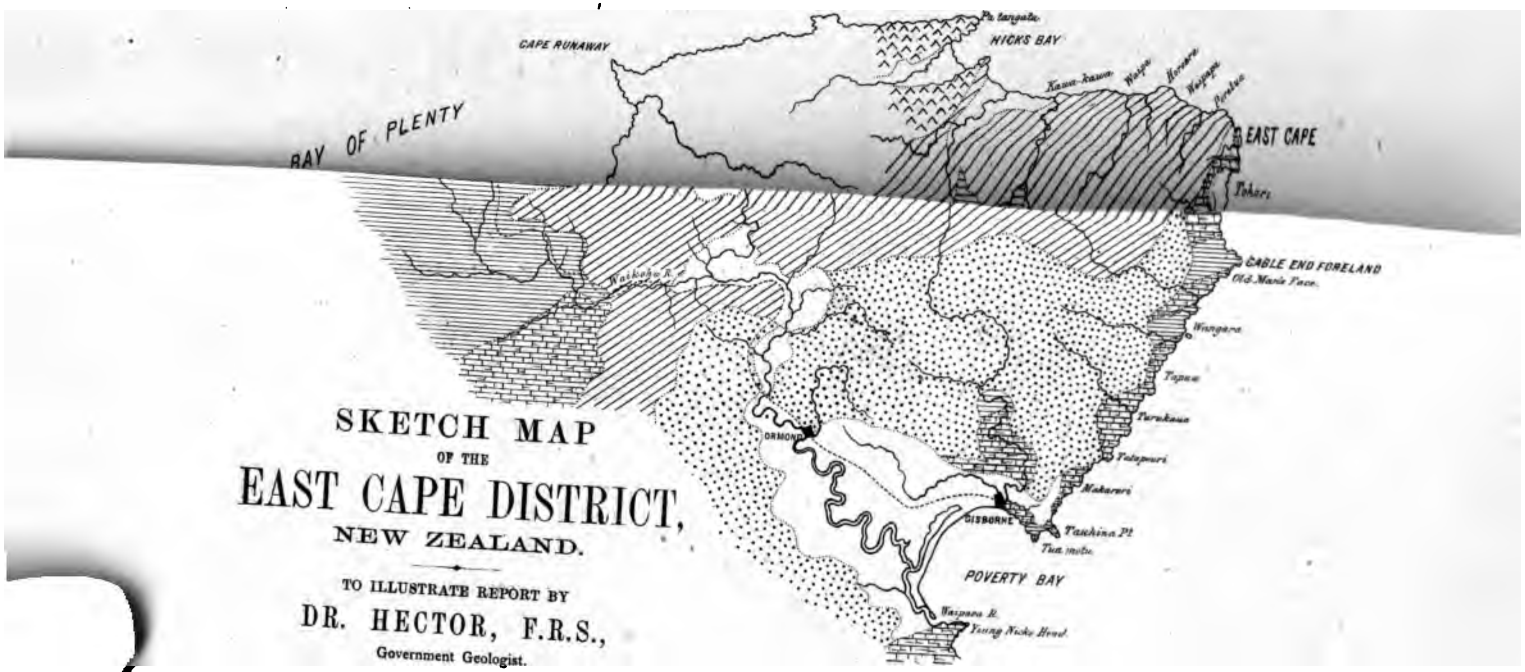
II.—UPPER TERTIARY.

Ormond Series (No. 2).—Shell limestone, sandstones with calcareous bands and concretions, and loose sandy conglomerates, containing fossil shells. This formation caps the top of the low hills between Gisborne and Ormond, and extends up the valley of the Waipara as far as Rangatira Flat. It appears to represent in the district the calcareous beds of Scinde Island at Napier, but contains less lime as a rule. The limestone behind Ormond belongs to this formation, but would seem to be a local deposit.

III.—LOWER TERTIARY.

Tawhiti Series.—This is a very extensive formation, and has been sub-divided into eight groups for convenience of reference. It covers a very large area of the surface in the district, forming an undulating plateau, cut into deeply by valleys. Towards the west it forms the

GEOLOGICAL SURVEY OF NEW ZEALAND.



SKETCH MAP
OF THE
EAST CAPE DISTRICT,
NEW ZEALAND.

TO ILLUSTRATE REPORT BY
DR. HECTOR, F.R.S.,
Government Geologist.

1874.

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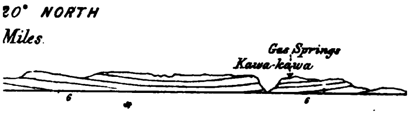

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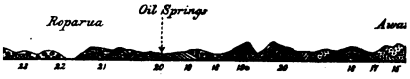

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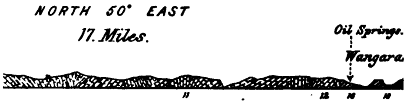

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summit-level of the country between the source of the Waipara and Hikurangi as a flat range of hills of moderate elevation, and is exposed along the coast in bold bluffs from a few miles south of Tologo Bay to Tokomarua, and again from the East Cape to Hick's Bay. Its subdivisions, as shown in the section, are as follows :—

No. 3. Blue sandy clay.
No. 4. Brown sandstone (Pectunculus beds).
No. 5. Clay marl (Struthiolaria beds).
No. 6. Tough brown sandstone (Cucullæa beds).
No. 7. Coarse sandstones (Ostrea beds).
No. 8. Fine-grained calcareous sandstones (Fan coral beds).
No. 9. Laminated sands (Venus beds).
No. 10. Coarse conglomerate. This is very local, and confined, so far as yet known, to one locality near Tuparoa.

IV.—Cretaceo-Tertiary.

Turanganui Series.—This is an important formation, for, although it does not appear over a large surface area in the district, it is exposed along a great extent of the coast line forming what is locally known as Papa Rock, which, by its toughness, offers considerable resistance to the encroachment of the sea, which wears it into long flat reefs with sloping surfaces.

This formation comprises an Upper and a Lower group, and it is not yet quite certain whether these should not be classed as separate formations; but the evidence obtained in other parts of New Zealand makes it advisable to combine them for the present. They have an enormous thickness, probably not less than 7,000 feet, and nearly everywhere are inclined at high angles, and have been much faulted and disturbed before they were planed down by the action of the sea, and overlaid by the foregoing tertiary strata.

The formation is sub-divided as follows into sections :—

No. 11. Calcareous green-sands (Nummulite beds).
No. 11. Tough clay marls.
No. 12. Gritty sandstone, with Nummulites.
No. 13. Yellow limestone and chalk marls, with flinty concretions.
No. 14. Chalk marls, with brown concretions.
No. 15. Green-sands, with conglomerate and plant remains.
No. 16. Green marly sandstones, with plant remains.

V.—Lower Cretaceous.

Awanui Series.—This formation is important from being the oldest group of rocks that is found in the district, and from the fact that the occurrence of oil or gas springs are invariably associated with its appearance at the surface. It comprises the following strata:—

No. 17. Black shales, with flakes of gypsum.
No. 18. Calcareous shales, with brown coloured concretions of large size.
No. 19. Bituminous limestones.
No. 20. Bright green sandstones, with calcspar and concretions containing phosphate of lime.
No. 21. Fine grained sandstones, with layers of dark shale.
No. 22. Coarse concretionary sandstone, weathering into large boulders.
No. 23. Dark green ferruginous sandstone.

Throughout this formation fossil shells occur frequently, among which are several large species of Inoceramus, Belemnites, and other forms characteristic of the Jurassic rocks in other parts of New Zealand.

In the sandstones masses of carbonized wood occur, but no distinct coal seams have been found. Stratum No. 5 is in general a flaggy limestone, but in some places is charged with bituminous matter, so as to acquire a dark colour, and is the only bed yet found in the district which affords any indication of the presence of oil. It is not, however, to be considered as the source of the oil, but merely as a reservoir in which it has locally accumulated under favourable circumstances.

In the area upon the map, which is marked as occupied by Formation V., there is included a large extent of still older rocks which form the base of Hikurangi Mountains. These have not yet been examined, so that in the meantime they are not separately indicated on the map, while they do not appear in any of the sections as seen along the coast.

The position of the oil spring intended to be worked by a company already formed for the purpose, is shown on the map to occur where a ridge or anticlinal fold of the Jurassic rocks appear at the surface, forming a narrow strip running nearly east and west, and flanked on both sides by the Tawhiti series—Formation III. The older formation has evidently been brought to this position by a local disturbance of the strata, as the younger formation, with its characteristic fossils, may be seen to be tilted at an angle of 60°, the junction being immediately behind Mr. Cuff's station, and crossing the creek up which the road leads to the oil springs, about 30 chains above its junction with the Waipara.

The oil springs are situated on the top of a hill, at an elevation of 1,300 feet above the sea.

The actual rock from which the oil escapes cannot be seen, but, judging from the run of the beds exposed in the section afforded by the creek, it would appear to be from the outcrop of a stratum of variegated marl, which in the creek bed dips at a high angle to the S.E., and is overlaid unconformably by thick beds of coarse dark coloured sandstone; but on the top of the hill, immediately to the eastward of the oil springs, there is an outcrop of green sandstone, which I am inclined to think belongs to the lower part of the formation, in which case the marl stones must have a trough like arrangement.

The oil rises to the surface, accompanied by water, so that there must be a true artesian spring, deriving its pressure from the high ground lying to the N.W. Whether the spring follows a vertical fissure, or escapes to the surface along the junction of the two formations, or along the lines of bedding, can only be determined by boring. The fact that no oil escapes in the lower ground, which it might be expected to do, favours the first view of the question, as unless it follows a fissure it is difficult to see why the water with the oil should rise to such a height, and escape at the summit of a narrow ridge surrounded by deep gullies.

The width of the belt of older marls when cut through by the Waipawa and Oil Creek is not more than half a mile. In the bed of both streams there are large boulders of igneous rock, which may be derived from a conglomerate at the base of the tertiary series, but a similar rock also occurs in the vicinity of the Hot Springs, behind Waipiro, and where there is no overlapping of the tertiary strata to account for its presence, so that it is possible there may be a dyke of igneous rock crossing the district, to which the dislocation of the strata may be referred.

A further examination of the country between Waipaoa and Hikurangi can alone determine this point, but in any explorations that are made in the vicinity of the oil springs the possible existence of such a dyke should be kept in view, as if its direction could be determined in relation to the strike of the older strata, it might help to explain the position of the oil springs. The chalky marls, variegated clays, and limestones of Formation V., as seen in Oil Creek (the creek up which the track goes), strike N., 55° E., with a dip of 50° to the S.E. The tertiary strata of Formation III., which overlie these older strata, strike east and west, and have a dip to the south of 60° along the junction that runs over the hill to the south of the oil springs, but they gradually flatten as they follow down the valley.

James Hector, Director.

GEOLOGICAL REPORTS.

NOTES ON THE GEOLOGY OF THE CLENT HILLS AND MOUNT SOMERS DISTRICTS, IN THE PROVINCE OF CANTERBURY.

TO ACCOMPANY A GEOLOGICAL MAP AND ELEVEN GEOLOGICAL SECTIONS.

By JULIUS HAAST, Ph.D., F.R.S.

21st February, 1873.

THE following notes embrace the results obtained during three journeys in the District under review, of which the first was undertaken in the autumn of 1861, the second in the same season of 1864, as Provincial Geologist of Canterbury, and the last during the months of January and February of the present year, for the Geological Survey of New Zealand. Being thus already fully acquainted with the general geological and topographical features of the country, I was enabled to devote, during my last journey, some time to detail examinations of several localities, so much wanted for a thorough understanding of the geology of that highly interesting region on both banks of the Ashburton.

In my preliminary Report on the Coal Fields of that District (Reports of Geol. Expl., 1871–2, p. 141) I have already given its general features, of which I shall here offer a fuller *résumé*, adding some details of purely scientific interest.

In my Report on the formation of the Canterbury Plains, published by the Provincial Government of Canterbury, in 1865, I pointed out that, owing to the enormous glaciation this district had been subjected to, the front ranges between the Ashburton and Rangitata were of less altitude than they generally are all along the western side of the Canterbury plains. I showed in the Report referred to, that a huge glacier descended in this opening to the plains, consisting of the united ice masses of the Ashburton, and of portions of the Rangitata and Rakaia basins—the two latter not finding room in their own valleys for the whole of their own glaciers to be brought down, and thus anastomosing by lateral depressions with the Ashburton glacier.

By this means the ranges in the district under review were subjected to exceptionally great glacier action and consequent denudation.

Thus most of the ranges are very ice-worn, their sides and summits often covered with morainic accumulations, or with those brought down by huge glacier torrents; several of them appearing as *roches moutonnées*, of which Trinity Hill and the smaller rocky hills in its neighbourhood are characteristic forms.

Whilst on the one hand a great deal of the geology of the district is thus concealed under these newer deposits, on the other hand the lateral valleys joining the main drainage channels have since the termination of that enormous glaciation been cut deeply into the ranges, in order to adjust their level to that of those principal valleys, and by which splendid sections have been laid open in almost numberless localities.

All the ranges in the district, with the exception of Mount Somers, which, however, stood with its main mass above the line of glacier action, do not rise to an altitude of 5000 feet.

In my Report on the Malvern Hills, Oct., 1871 (Reports of Geol. Expl., 1871-2, p. 1), I have given a detailed description of the older sedimentary rocks, and I showed that their eastern termination and lowest visible beds consist principally of conglomerates, and other rocks of littoral origin. This particular feature is still more strongly developed in the Ashburton district, where some splendid sections enabled me to follow these lowest beds for several miles, so that their structure and sequence could be well ascertained.

These older sedimentary rocks appear in a semicircular form stretching from the Moorhouse range in the south, over Trinity Hill and the Clent Hills to the Mount Somers range and Mount Winterslow in the north—here reaching again the Canterbury plains. The huge bay thus sketched out existed already in the epoch prior to the eruption and deposition of the basic rocks (melaphyres), which are at least of young secondary age; at the same time, the different small outliers of the old sedimentary rocks which occur in various localities in this former bay, prove that they once formed small islets or shallows in it.

There is, as I shall point out in the sequel, some difference in the character of these old sedimentary strata, going from east to west. It appears that whilst in the ranges near the plains we observe mostly truly littoral beds, the deposits of huge rivers entering here the palæozoic sea, further to the west, as, for instance, on the banks of the Upper Rangitata, we find their horizontal equivalents as rocks of a different character. They consist of shales and shaly sandstones with marine shells, mostly Brachiopods, showing that they were deposited in deeper water than the Clent Hill beds, and some distance from the palæozoic coast-line.

The Clent Hill strata, the principal object of examination, not yielding, however, any fossil shells, I proceeded to the Rangitata, where marine exuviæ were found by me more than ten years ago in the deep gorges of the Mount Potts Range, to see if I could not at least connect both beds in some way by the sequence of the outlying beds, which, as I shall show in these pages, I have been able to accomplish. Unfortunately the time at my command would not allow me to continue the detail survey from the western slopes of Mount Potts to the Upper Ashburton plains, over some ten miles of very rough, mountainous country, but I may state that I possess sufficient material, from having once crossed that portion of our alpine ranges, to satisfy myself that the same lower beds will continue to appear wherever water-courses have cut deep gorges into the ranges, or the flexures of the strata bring the lower beds up to the slopes of the mountains.

The following is the usual sequence of the lowest sedimentary rocks, as they appear in the Clent Hills district in an ascending order.

The lowest beds are usually :

1. Slates greyish, sometimes very siliceous, alternating with sandstones, the latter gradually becoming of a coarser grain, so as first to assume the character of a grit, and afterwards of a pebble-bed.

Upon them repose :

2. Thick bedded conglomerates, in the Clent Hills several hundred feet thick.

In these conglomerates occur large carbonaceous markings, as if from drift trees; sometimes they are fucoid-like; smaller beds of sandstone are interstratified, partly ferruginous, partly full of obscure remains of plants.

Well rolled boulders of greyish or greenish coarse sandstone, from the size of a child's head to that of a bean, formed the principal portion of the rocks, mixed sometimes with boulders or pebbles of chert and lydian stone. Occasionally a few pieces of quartz, porphyry, and gneiss, which I found only after some search, connect them with the beds of the Puddingstone Valley, in which the latter occur in nearly equal proportions with boulders of sedimentary origin, whilst the sections of Trinity Hill show the gradual change from the one into the other.

These conglomerates, like the whole series to which they belong, are much jointed, often a system of four distinct joints being well developed, crossing each other at various angles, and cutting with sharp planes through the hardest boulders in the conglomerates.

The palæozoic outlier in the Gawler Downs belongs, without doubt, to this series.

3. Shales alternating with gritty sandstone, coal-sandstone, and bands of clay-ironstone now follow. Some of the sandstones are full of the impressions of fossil ferns, others full of those of roots or of drift timber. Flattened stems of trees are also enclosed, often of considerable size, the bark altered to a scaly anthracitic coal (culm)*, the interior filled with sandstone, often of a much finer grain than the surrounding rocks.

Amongst the fossil flora I observed, *Pecopteris*, two or three species, *Camptopteris*, *Tæniopteris*, *Otopteris*, *Cyclopteris*, *Sphenopteris*, *Cycadites?* *Palæozamia?* *Taxites?* *Equisetites*.

The *Pecopteris* beds are usually distinct from the *Tæniopteris* beds. Some of the shales consist almost entirely of the leaves and stems of ferns.

Amongst them the beds of sandstone are generally the most important, some of them having a thickness of over twenty feet, although generally the arenaceous and carbonaceo-argillaceous strata alternate

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* The following analysis of two specimens of this culm was made in the laboratory of the Geological Survey in Wellington :—

1, *and* 2, *Bituminous Coals* (*Culm*).

Colour intensely black, lustrous, very fragile.
Colour of powder black, that of ash light buff.
No. 1 cakes freely, the other even more so.

APPROXIMATE ANALYSIS.

	No. 1.	No. 2.
Water	2·27	2·12
Fixed carbon	55·10	50·04
Hydro-carbon	11·95	13·44
Ash	30·68	34·40
	100·	100·

Evaporative power of No. 1 = 7·1.
„ „ No. 2 = 6·5.

rapidly with each other, and are occasionally only a few inches thick. The whole thus have a ribboned appearance.

This series is together also several hundred feet thick.

4. They are covered by conglomerate beds like No. 2, but of smaller dimensions.

5. They are overlaid by a series of shales and sandstones, the latter having sometimes a semi-crystalline structure, and being of considerable thickness.

6. Upon them repose very thick beds of a fine-grained sandstone, which has the peculiarity that its matrix or cementing medium generally decomposes to a white powder. Many years ago, comparing this rock with similar rocks in Europe, I applied to it the name of Kaolin Sandstone, with which it has a close resemblance at least in outward appearance. Gradually this rock becomes more argillaceous, and is largely interstratified with shales.

7. The next horizon is formed of several beds of chocolate-coloured or brick-red slates. They are of various thicknesses, and alternate with greyish, greenish, or purple slates.

They are more or less arenaceous, of a very distinct character, and have been traced by me over a great deal of ground in several localities in this Province, as well as to the more northern portions of this Island. From their lithological character and position, I believe them to be the horizontal equivalent of the cherts and diabasic beds which occupy the same horizon in the Malvern Hills and elsewhere.

These beds are again overlaid by sandstones, shales, and slates of various characters of which I have given the principal characteristics in my Malvern Hills Report.

In order to examine more closely the lithological character of the Mount Potts beds in the Rangitata, I paid another visit to that locality, with the following results :—The beds, Nos. 1, 2, 3, and 4, of the Clent Hills series, are here represented by a great thickness of dark shales, often becoming so slaty that they may be termed clay slates, alternating with thinner layers of sandstone, sometimes with a ferruginous or calcareous matrix.

Amongst them occur a few beds of conglomerate, which fairly may be termed bone beds, as they consist, besides boulders and pebbles of light coloured slates, of great quantities of well-rounded pieces of bones and broken shells. The former show often considerable dimensions. I was thus able to measure the proximal end of (probably) a humerus, which

I found to be eight inches across, and some other bones of similar dimensions; however, the bones, as before observed, were so much rolled, and the cementing medium of such considerable hardness that I was unable, with the tools at my command, to procure any characteristic specimens, but I have no doubt that they are of Saurian origin. No teeth were visible amongst this bone breccia.

The whole of these strata form a large anticlinal in Fossil Gully, and they are well and clearly exposed in a deep and rocky gorge for several miles.

They contain the following genera, and probably species:—*Orthis spinigera*, *Spirifera (lineata, lata, oviformis, duodecimo-costata)*, *Producta*, *Atrypa*, *Euomphala*, *Murchisonia*, *Orthoceras*, *Encrinites*, of which many resemble, or are closely allied to, Australian forms from the New South Wales coal field series.

They are covered by the same succession of beds as occur in the Clent Hills, beginning with No. 5, and I may here observe that I was able to trace some of these upper beds, as, for instance, the chocolate coloured slates, all the way from near the summit of the Mount Potts range, to the foot of Mount Potts, five miles to the south.

This is therefore good and, as I think, conclusive evidence that the Clent Hills and Malvern Hills plant beds, notwithstanding they contain the remains of a plant closely allied to *Tæniopteris*, are nevertheless of great age, and if we adopt Professor McCoy's conclusions for the Mount Potts fossil shells, at least carboniferous. Moreover, there is no doubt that they are of the same age as the formations which in New South Wales contain the fine coal fields.

The relations of these palæozoic beds are shown, for comparison, in section 1, and whilst the more westerly Mount Potts beds exhibit only one huge anticlinal arrangement, those in the Clent Hills have undergone greater flexures, of which in a distance of three miles, six synclinals are clearly exposed in Fern Gully, and to the elucidation of which I devoted some time.

The same sequence of the palæozoic sedimentary beds is shown in all the sections I examined, of which several of the annexed drawings give the details, and to which I beg to refer.

As before observed, the more we advance towards the Canterbury Plains, the more we are sure to find the conglomerates in exposed positions, having by their hardness, without doubt, resisted most effectually the disintegrating influences here at work for numberless ages, and before the next or melaphyre beds were deposited.

Melaphyre Formation.

Although there are characteristic tufa beds interstratified with the melaphyres, no fossils of any kind have been found in them at present, and thus it is impossible to state when those eruptions, which were on a gigantic scale, took place, by which the melaphyres and their accompanying tufas were deposited upon the sea-bottom. I can only repeat what I stated concerning them in my Report on the Malvern Hills, namely, that they repose on the edges of the older sedimentary strata, which, previously to the eruption of these basic rocks, had undergone great changes and denudations, and that since then no alterations of importance, except the rising of the land, had taken place.

Owing to the many fine sections, the junction of the lower melaphyre streams, or their tufaceous deposits, upon the water-worn surface of the palæozoic rocks, is well exposed, and can thus be easily studied.

A glance at the Geological Map will show that these melaphyres have been deposited in a bay fifteen miles long and nine miles broad, and that before the next, or acidic, beds were formed, they, in their turn, underwent enormous denudations. I may here add that generally in other countries the acidic formations (quartziferous or felsitic porphyries) constitute the lowest beds, whilst the melaphyres, or basic rocks, repose upon them—our beds thus differing in this respect. Of this denudation the isolated system of the Gawler Downs forms a notable instance, as it is only a remnant of a once continuous series of beds which all around have been removed, often for many miles.

It would lead me too far to give a description of all the different forms under which these rocks occur, but a few examples will suffice, I think, to show this. Thus, on the very summit of the Clent Hills we find a *coulée* of melaphyre about thirty feet thick, with great joints vertical to the flow, which, in this instance, is 19° to the N.N.W., lying directly upon the palæozoic (conglomerates) without any tufas between them. The sedimentary beds themselves appear to have undergone no change, with the exception that they have assumed a reddish tinge for a thickness of several feet.

On the other hand, in some deep gorges of the same range—as, for instance, in Burnt-hut Creek, on the northern side—the sedimentary rocks near the contact are very much decomposed. Upon them lie six inches of bluish clays, which gradually alter to melaphyre tufas (wacke) full of sub-angular pieces of melaphyre. These latter beds, after having obtained a thickness of twenty feet, assume the form of amygdaloids, full of geodes and concretions of quartz in all its varieties, and having occasionally the pores and hollows filled with or lined by green earth (delessite).

Gradually these earthy beds, which disintegrate easily to a blackish loose powdery mass, become more compact, and have the appearance of lavas of a reddish colour, forming apparently the lowest portion of the first compact melaphyre stream. We may thus assume that the first melaphyre *coulée* was only deposited here some time after the beginning of the melaphyre eruption had taken place in the district, during which the tufaceous beds had here first been formed.

Again, in another locality—in McGregor's Creek and at the foot of the Mount Somers range—the palæozoic rocks are remarkably decomposed, forming green earthy beds, upon which hard melaphyres—amygdaloids—repose directly, without tufas between them.

In the Gawler Downs we find agglomerates and tufas upon the palæozoic rocks, the former, in their turn, being covered by melaphyres having generally tabular forms. The altitude to which the melaphyres rise is about 4000 feet, at which they occur both in the Clent Hills and in the isolated hills between Mount Somers and Mount Winterslow.

Some of the streams are of great thickness and extent, as I was enabled to trace them for from five to six miles. Their number is also very great, to which, amongst other localities, the Gawler Downs give us a splendid insight; streams of melaphyres, many of them standing nearly vertical—a dip of 79° to 82^b, generally to the E.S.E., being common—alternating in an almost endless succession with tufas of various character. Some of them, full of concretions of green earth, are true amygdaloids, or are full of geodes of agate, chalcedony, and all the numerous varieties of quartz usually found in these old basic rocks, and vividly reminding me of Oberstein, in Germany.

The lithological character of the rocks under review is very varied. We find some of which the component parts are so distinctly crystallized that they would be mistaken for dolerites, others are more porphyritic, some so compact that they appear like basalts, whilst a few of them have a pitchstone-like appearance. When in an undecomposed state, they are generally black, with greenish, bluish, or reddish hues. They contain numerous minerals as accessories, such as agate, chalcedony, amethyst, jasper, calcareous spar, spherosiderite, delessite, and epidote, but I was unable to find any traces of ores, and the different localities which were pointed out to me as containing copper ores proved unfortunately to consist only of masses of green earth, as accessories to the rocks, or colouring them intensely.

QUARTZIFEROUS PORPHYRIES AND PITCHSTONES.

The basic rocks just described are covered in many localities by a series of quartziferous porphyries and pitchstones, which rise in Mount Somers to 5223 feet. An examination of the junction of these two eruptive rocks in several localities, showed that the older rocks had undergone considerable denudation, or, at least, that their surface had been altered considerably by aqueous agency before the next beds were deposited upon them. Thus, to give here one instance, in Junction Creek in the Clent Hills, which joins the Stour, the uppermost beds of the melaphyres consist of a very decomposed amygdaloid, which gradually changes into green tufas, the lowest beds of the quartziferous porphyries; upon them repose pitchstones, from a greenish-white colour gradually assuming a black tint, and becoming very vitreous. The porphyries which lie upon them, or, more correctly stated, of which they form the lowest portion, have a hyaline base, follow each other in many streams, but generally with the pitchstones between them.

These porphyries are confined to the northern and western portion of the district under review. Although of a great variety of texture and colour, in the main they resemble the rocks of the same description and age occurring in the Malvern Hills, a porphyritic structure with grains of quartz and small crystals of garnets (almandine) being predominant.

I have already alluded to the fact that these porphyries lie directly in some localities upon the melaphyres, but in other localities more towards the south and east they repose upon the palæozoic sedimentary rocks, the streams of which they are composed following the outlines of the former sea-bottom, and being at the same time accompanied by a succession of truly sedimentary rocks of great variety.

In speaking of the palæozoic sedimentary strata I stated that they form outliers in several localities, having doubtless been former islets or shoals in secondary seas. Two of these which have caused the former acidic rocks to conform to their configuration, are situated on the southern slopes of Mount Somers—one on the eastern side of Chapman

Gully, or Woolshed Creek, where the latter leaves its remarkable rocky gorge cut across Mount Somers, the second on the south-eastern termination of Mount Somers in the Cox Hills. In the former locality, the lowest portion of the junction beds is hidden, but in the latter it is so clearly exposed that there remains not the least doubt as to the true sequence and character of the beds under review.

Section No. 5 gives the details of this interesting junction, of which, in my Malvern Hills Report, section ixg., I gave another instance, and I consider these details so remarkable that I may be allowed to transcribe them here from my field-book.

Upon the palæozoic sedimentary rocks, consisting principally of coarse sandstone decomposing to a loose ferruginous gravel, repose thick beds of green sands, which gradually alter to yellowish and white quartzose sands. Thickness, about 500 to 600 feet. They are capped by beds of ferruginous shale 3 feet thick, overlaid by 4 feet of snow-white sands.

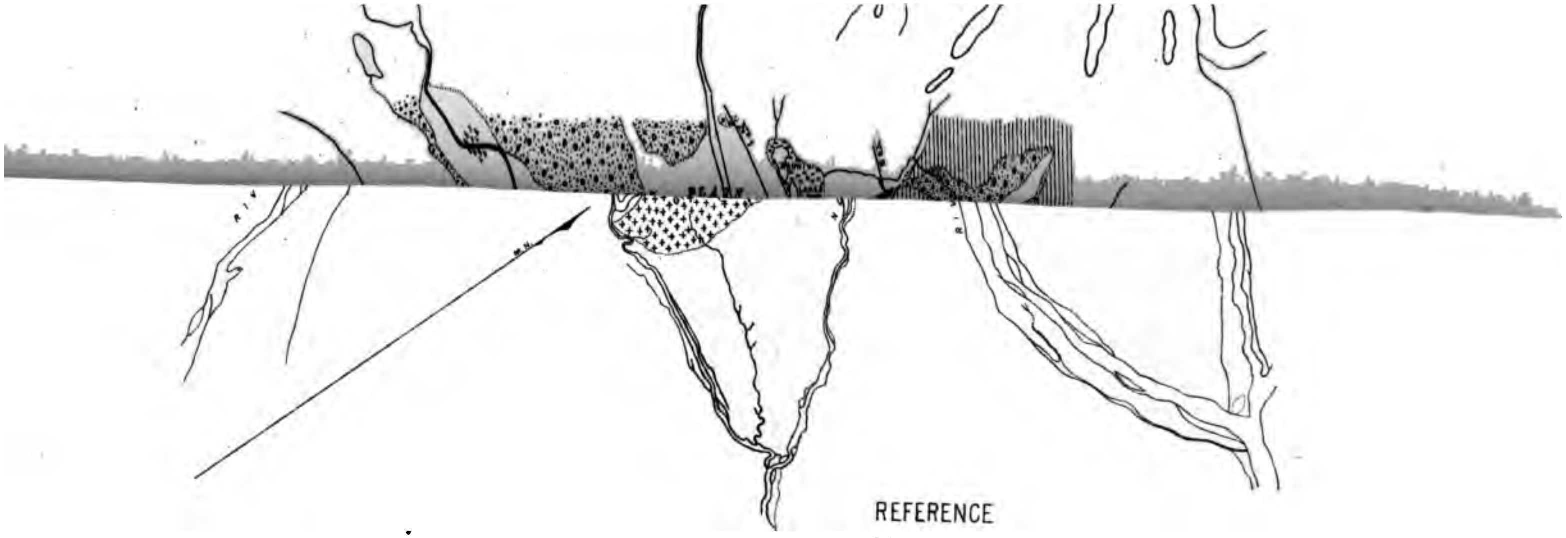
Upon them repose 20 inches of shales, full of impressions of leaves, but unfortunately with scarcely any pieces large enough for recognition. Some of these leaves, however, I recognised as being of a truly dicotyledonous character; and I think this of some importance, as it proves at least one great fact, namely, that these enormous masses of quartz porphyries were deposited after a flora with dicotyledonous leaves—and of which the oldest known are those of Aix-la-Chapelle in Germany, and of the age of the upper chalk—had been already in existence in New Zealand.

These shaly beds are again overlaid by a great thickness of sands, mostly of a pure white colour, and with veins and irregular portions of yellow or salmon-coloured hues.

They are covered by shales, with a dip of 46° to W.S.W., followed by 3 feet of a partially altered brown coal, showing sometimes still the woody structure; this seam is covered by 16 inches of gritty sandstone.

Then follow, in ascending order :—

12 inches of yellowish or bluish tufaceous clays, 6 to 8 feet of shaly beds, with indistinct remains of plants, 3 feet of bluish or greenish tufaceous clays, 1 to 2 feet of porcelain jasper, evidently altered and burnt by the next beds of an eruptive character. These porcelain jaspers contain already lapilli or even smaller blocks of pitchstone enclosed in them. They gradually alter into a whitish tufaceous mass,



GEOLOGICAL MAP
of the
CLENT HILL DISTRICT.

PROVINCE OF CANTERBURY NEW ZEALAND

BY
Julius Haast Ph.D. F.R.S.

SCALE.

REFERENCE

I ☐ a. River beds – Recent Alluvium.
b. Swamps.
c. Post-pliocene Alluvium.

II ▨ Glacier Deposits.

III ▤ a. Limestone Middle Tertiary.
b. Sands with fossil beds. Middle Tertiary Greensands.
c. White Sands, and Green Sands.

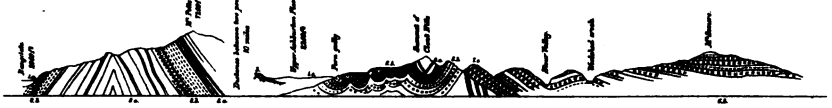
IV ■ a. Brown Coal beds.
b. Brown Coal beds with Tufas.

V ^^^ a. Palagonite and Basaltic Tufas.
b. Dolerite.

VI ××× a. Porphyritic Tufas. b. Porphyry Quartziferous & Pitchstone.
c. Porphyry Quartziferous & tufaceous.
d. Pitchstone Agglomerate. e. Porphyry Tufa.

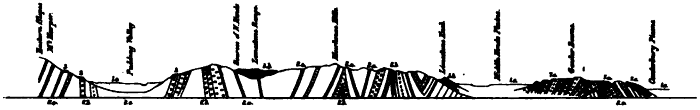
VII +++ a. Palla.
b. Melaphyre.
c. Melaphyre. Amygdaloidal. & tufaceous.

VIII ▥ a. Red Slates.
b. Conglomerate, with plant beds.
c. Sandstone. Shales. Slates. &c
} Palaeozoic. Lower carboniferous, or upper Devonian.



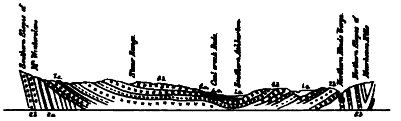
FROM WESTERN SLOPES OF Mt POTTS, RANGITATA, TO EASTERN SLOPES OF Mt SOMERS, W. TO E.

Sec: I.



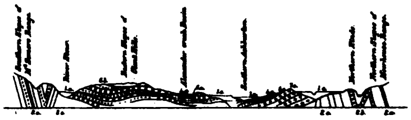
FROM EASTERN SLOPES OF Mt HARPER TO EASTERN SLOPES OF CAWLERS DOWNS FROM E. TO W.

Sec: II.



SOUTHERN SLOPES OF Mt WINTERSLAW, TO NORTHERN SLOPES OF MOORHOUSE HILLS, N.E. TO S.W.

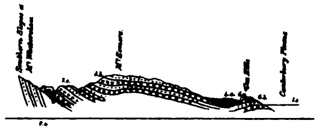
Sec: III.



SOUTHERN SLOPES OF Mt SOMERS RANGE, TO NORTHERN SLOPES OF MOORHOUSE HILLS, N. TO S.

Sec: III B.

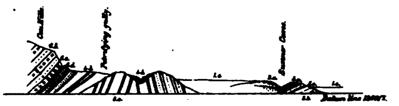
SCALE OF FEET.



SOUTHERN SLOPES OF Mt WINTERSLAW, TO EASTERN SLOPES OF COX HILLS, N. by W. TO S. by E.

Sec: IV.

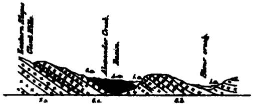
SCALE OF FEET.



PETRIFYING GULLEY, & SUMMER LIMESTONE CAVE HILLS, N. by W. TO S. by E.

Sec: V.

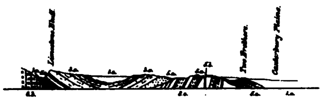
SCALE OF FEET.



ALEXANDER CREEK, & STOUR CREEK, N. by W. TO S. by E.

Sec: VI.

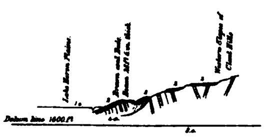
SCALE OF FEET



LIMESTONE BLUFF, ASHBURTON, TO TWO BROTHERS HILL, N. by W. TO S. by E.

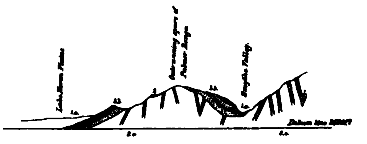
Sec: VII.

SCALE OF FEET



LAKE HERON PLAINS, TO WESTERN SLOPES OF CLENT HILLS, N. by W. TO S. by E.

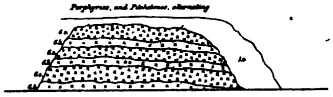
Sec: VIII.



WESTERN BANKS OF SMYTHE, TO LAKE HERON PLAINS, N. by E. TO S. by W.

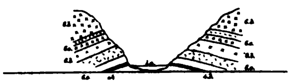
Sec: IX.

SCALE OF FEET.



ENTRANCE OF GORGE OF WOOLSHED CREEK Mt SOMERS.

Sec: X.



ACROSS WOOLSHED CREEK, Mt SOMERS.

Sec: XI.

SCALE OF FEET.

consisting of lapilli and ashes cemented together, without doubt the result of the destruction of pitchstones during an eruption.

These beds are full of angular or sub-angular pieces of black pitchstone, evidently much decomposed, and from 1 inch to 20 feet in diameter; the whole having a thickness of at least 100 feet. They are capped by a stratum of pitchstone about 10 feet thick, upon which quartziferous porphyries follow, first with a hyaline, afterwards with a more felsitic matrix.

This first great stream forms the lowest of a great succession of similar ones rising to the summit of Mount Somers, that is to say, the whole have a thickness of more than 3000 feet. Towards the Ashburton, the succession of the streams is not so well shown; but on the northern flanks of Mount Somers, where that fine mountain falls in some localities abruptly for more than 1000 feet in almost perpendicular cliffs, the position, nature, and succession, are well exhibited.

Some of the *coulées*, occasionally of great thickness, have a more trachytic structure towards the centre, whilst the smaller ones are generally more hyaline, or at least felsitic, usually with selvages of pitchstone on both planes. In fact they may fairly be compared to lava streams of the present day, showing the same process of cooling, although, owing to different circumstances and mineralogical constituents, the magma out of which they originated naturally assumed different forms.

Another interesting section (No. 11) is exposed in the deep gorge of Chapman's, or Woolshed Creek, as it is sometimes called. Here the lowest beds consist of whitish or yellowish tufas, with small lapilli and fragments of pitchstone inclosed, and being separated by a few thin seams of impure brown-coal. The fragments of pitchstone become gradually larger, and closely packed together, until they form one uniform sheet, over which again the quartziferous porphyries, possessing a hyaline or felsitic matrix, rise in a succession of streams to a high mountain mass several thousand feet thick. The vertical dimensions of the streams vary considerably. There are some which are only a few feet, others which are more than 100 feet thick, which, as before observed, can be well ascertained in the nearly vertical sides of the northern upper portion of Mount Somers, where they appear in a nearly horizontal position.

In several localities, the alternation of felsitic and pitchstone beds is well exposed, of which section No. 10 gives the interesting details.

This instructive section occurs on the left bank of Woolshed Creek, at the entrance of the gorge.

There are in ascending order :—

Pitchstone, black, very vitreous	10 feet.
Felsitic porphyry	21 "
Pitchstone	12 "
Felsitic porphyry	15 "
Pitchstone	10 "
Felsitic porphyry	12 "

As I believed that here also the pitchstones were simply the upper and lower faces of the porphyry streams, flowing over the bottom of the sea, I searched for the junction of the different streams in or near the centre of these hyaline rocks, but without result, on the contrary, the junction between the rocks of different character is sharply defined, so that it appears as if each bed had been formed by a distinct eruption. A confirmation of such an hypothesis, at least in this instance, is also offered in the fact that the streams of felsitic porphyries contain fragments of pitchstones enclosed, while the beds of pitchstone abound in enclosures of angular pieces of porphyry.

In other localities there is no doubt, however, that the pitchstones form the lower and upper portions of the porphyry streams, the gradation between the two extremes being extremely interesting and curious. I may here observe that some of these intermediate rocks answer well to Naumann's description of *pichthonstein* or *pechsteinfelsit.*

Concerning the source or sources whence these eruptive rocks were ejected, I think we have to go more to the north, where, on the banks of the Northern Ashburton, another porphyry system rises in a conspicuous mountain form, surrounded on all sides by sedimentary palæozoic ranges. However, in some localities in the deep gorges, on the northern side of Mount Somers, occur some pitchstone beds, mostly concealed by detritus from the ranges, which appear to form dykes passing through the palæozoic sedimentary and the older basic eruptive rocks, and which might possibly be some of the channels by which the porphyries made their appearance. If further examination proves this to be correct, there is no doubt that the rapidly cooling magma, filling the narrow channels after the eruption, assumed the hyaline structure. A similar occurrence of dyke-like pitchstones is to be observed near the summit of the Rockwood Ranges, in the Malvern Hills, and to which the same origin might be assigned. As I shall show in the sequel, these rocks are nowhere covered with the lower fossiliferous beds observed in the Malvern Hills (cretaceo-tertiary), only the upper portion of these beds (the so-called Curiosity Shop formation) reposing upon the flanks of the outrunning spurs of Mount Somers; nevertheless, there is no reason to doubt that they are of the same age as the quartziferous porphyries of the more northern region, and for which a cretaceous age might be claimed.

Before leaving this interesting formation, which allows us in its numerous beautiful sections to study it in all its details, I may add that there is another well authenticated instance of young felsitic porphyries in the Southern Hemisphere, Charles Darwin having observed deposits and dykes of felsitic porphyry amongst the cretaceous clay-slates which that illustrious naturalist observed on the eastern side of Ponsonby Sound, Terra-del-Fuego.

YOUNGER SEDIMENTARY FORMATION.

In my Preliminary Report on the coal deposits of the Ashburton district (Report of Geol. Expl. 1871–2, p. 141), I had already occasion to point out that the porphyry conglomerates, brown coal-bearing, and Saurian beds above them were missing. I added, however, that there are some series of beds containing seams of brown coal, deposited in small basins in several localities, which possibly might be their equivalent in age, but that, owing to not observing any characteristic fossils, it was at present impossible to settle this point.

There are principally three isolated localities where seams of brown coal are exposed to view, of which two occur in depressions amongst the porphyries, whilst the third is found on the flanks of the palæozoic sedimentary rocks in the Lake Heron plains.

Beginning with the latter, of which section No. 8 gives the details, I have to observe that only a small remnant of what once must have been a large formation remains, the rest having been removed by the huge post-pliocene glacier, which here ploughed so effectually to the ranges. These beds lie against the palæozoic rocks, in a small bay scarcely 150 yards long, covered with morainic accummulations or alluvium. We owe their discovery to the occurrence of a small watercourse which has cut through the latter accumulations, thus exposing the former to view.

In ascending the hill-side close to the Clent Hill station, and after passing through ten to twelve feet of shingle deposit, the lowest beds belonging to this formation are reached, consisting of—

42 feet of loose ferruginous sands dipping E.S.E. 76°, and containing pockets and concretions of ferruginous clays. Upon them reposes—

A band of clay marls 12 inches thick, full of casts of a bivalve, allied to *Cyrene*, thus proving the fresh-water origin of the beds under review. They are overlaid by—

14 feet of arenaceous sands gradually becoming sulphurous, separated in many layers by small bands of clays, through which the whole obtains a well stratified appearance; they are succeeded by a bed of under-clays, several inches thick, upon which reposes a large seam of—

Brown coal, dipping E.S.E. 63°, 28 feet 6 inches thick, separated by several small bands of shales into different banks.

This seam of brown coal, of fair quality, is covered by loose quartzose sands, first white and afterwards assuming yellowish tints, and which, eighty feet above the coal seam, abut against the palæozoic rocks, here forming steep cliffs and being greatly decomposed, the whole overlaid, as before stated, by post-pliocene alluvium. It is evident from this section that these newer beds must have been formed in a bay, of which the lowest portion and the rocks on which they were originally deposited have disappeared, without doubt through the effect of glacier action.

On the opposite side of the valley—on the left bank of the river Cameron—in some slips amongst the morainic accumulations, I observed also beds of a similar character to those of the Clent Hill station. In one of these slips occur white, loose sands, with streaks of coaly matter, probably drift trees. They are succeeded by a seam of lignite 3 feet 2 inches thick, generally showing woody structure, covered by—

Sandy clays, with a layer of shale about one foot thick, the whole dipping N.E. 61°.

In another locality, a few hundred yards distant, similar beds occur, but so much disturbed that I was not able to ascertain their real position and extent. In any case the presence of these strata on the opposite side of the Lake Heron plains proves at least that we may anticipate the occurrence of seams of brown coal of great extent in that region, which owing to a great scarcity of firewood in the district will some day be of great value to its inhabitants.

A second basin, already of practical value, is situated in the neighbourhood of the junction of the river Stour with the Ashburton.

It occurs in a depression amongst the quartziferous porphyries, which, before the main river had cut through their eastern boundary formed here, doubtless, a ridge of considerable dimensions, behind which the sedimentary beds of lacustrine or littoral origin could be accumulated. This basin, somewhat triangular in shape, is about two miles broad and long. It appears that the porphyries had already undergone considerable denudation before the newer beds were formed, they having been deposited on the sides of steep escarpments and cliffs.

The lowest beds consist of porphyry tufas, lying generally at a high angle, and following the outlines of the spurs. They are of great variety in colour and texture, often with a fine ribboned appearance, white and yellowish colours being predominant. They are well exposed in Coal Creek; gradually they become darker, and are succeeded by shales in that locality, upon which a seam of brown coal of good quality reposes, fourteen feet in thickness, of which however only the lower portion of eight feet is extracted. This coal has a dip of 8° towards S.S.E.

The seam is capped by shales, with smaller seams of brown coal interstratified, and sandy clay marls, overlaid unconformably by post-pliocene alluvium.

On the opposite side, and on the southern banks of the river Ashburton, I discovered another portion of the same basin, consisting of porphyry tufas, shales, and two seams of brown coal, about four and five feet thick, separated by a few feet of inferior coal, or shale. However, as the outcrop was very much decomposed, the two might possibly belong to one seam, which can easily be ascertained by opening up the ground, which also here is covered by post-pliocene alluvium.

The deposits in Alexander Creek, a tributary of the river Stour, and of which section No. 6 gives the details, is doubtless only a portion of this larger Ashburton-Stour basin; the coal seams are, however, too small and too irregular to be of any practical value.

A third locality to which I alluded in my preliminary Report, is situated in the bight which is formed by the junction of the Cox range with Mount Somers. The beds forming this series, and which have generally a northerly dip of 15° to 18°, ranging between N.N.E. and N.N.W., consist first of porphyry tufas, white, yellowish, or sometimes black, from an admixture of organic matter, of fire-clays, shales, with a considerable series of seams of lignite ranging from two inches to five feet. These seams vary very much in character; some are turbary deposits, whilst others are formed of timber, the woody structure of the trees of which they are formed being still clearly visible. The coal is generally of inferior quality, and sometimes full of nodules and concretions of iron pyrites. Small bands of clay ironstone occur occasionally. Section No. 4 passes through this basin.

Finally, I may observe that these deposits are unconnected with the beds forming the next and more extensive series, so that we have (not being able to obtain characteristic fossils) no clue as to their real age.

THE LIMESTONE FORMATION.

The next series under review is of considerable importance to the district, as it contains large beds of limestone, and other deposits of equal economic value. Although still of considerable extent, we observe only remnants of an important formation which once covered uniformly the whole portions of the lower country, but which, owing to extensive denudation, principally by glacier and fluviatile action, has now disappeared in most localities.

The most complete section of these beds is to be observed on the northern banks of the Ashburton between Limestone Bluff and the Two Brothers. It shows that we have before us beds of various character, ranging from deep sea deposits, through others of intermediate character, to shallow water and estuary beds. This section also fixes the time when the submarine eruptions took place, of which we observe in several localities the former channels, and which are now filled with basalts.

The following succession of beds was observed by me, near and at the Limestone Bluff (section No. 7), and is here given in descending order:—

No. 1—Limestone, white on the summit of the ridge, in flaggy layers, consisting principally of pieces of shells and corals, and offering splendid material for the lime-kiln. Strike 290°, dip towards E.S.E. 55° - - - - - - -	about 15 feet.
No. 2—Changes into arenaceous limestone, forming thick beds without divisions - - - -	,, 70 ,,
No. 3—Dark brown volcanic tufas, with numerous lapilli of basaltic lava enclosed - - - -	,, 15 ,,
No. 4—Gradually this tufa becomes harder, formed of stratified layers of brown or green dirty colours, alternating frequently with each other, and becoming glauconitic towards the bottom - - -	,, 20 ,,

No. 5—Being underlaid by tufaceous calcareous sandstone - - - - - - - - - about 40 „

Gradually altering to—

No. 6—Calcareous greensands, becoming towards the centre almost black, from grains of glauconite - „ 30 „

No. 7—They are cut off from the lowest beds by several layers of shell limestone, consisting mostly of fragments of shells, and enclosing specimens of *Pectunculus*, of a small white *Ostrea*, and casts of a bivalve (*Mesodesma ?*) - - - - - - „ 10 „

No. 8—The lowest beds of the whole series are formed of quartzose sands of light colours, and of considerable thickness, which will be valuable for glass-making.

They repose on the slopes of much decomposed quartziferous porphyry.

More towards the centre of the section, and to the channel whence the submarine eruption took place, the beds 5 to 8 are missing. Here repose directly upon the palæozoic rocks, which occur as a small outlier, thick beds of a tufaceous or agglomeratic character, which in some localities such as the Two Brothers, consist entirely of palagonite tufa of an uniform texture, whilst a little nearer to the centre of eruption the compact dark mass contains numerous fragments of the same rock enclosed, but of a somewhat lighter colour.

On the opposite side of the river at the base of Mount Somers portions of the same beds are extensively developed, but only the higher series exposed to view, of which, amongst other localities, the district around the so-called Sumner caves is the most conspicuous and well-known. The caves owe their formation to a small creek which has washed out its way at the junction of the beds Nos. 1 and 2.

The palagonite tufas are here the lowest beds visible.

The calcareous beds contain *Pecten hochstetteri*, *Pecten athleta* (?) *Waldheimia lenticularis*, *Lima sp.*, *Ostrea sp.*, *Brissus sp.*, *Cidaris sp.*, and several others which connect these beds with those of the Curiosity Shop at the Rakaia, and at the same time with the Weka Pass limestone, which latter forms, according to my view, the last bed belonging to the Saurian formation. Another outlier of the same series, and proving that these beds extended once over a considerable portion of the country, is situated at the head of the northern Hinds (the so-called

Limestone range), and where the same succession of beds was also observed by me.

Although not included in the district of which a geological map has been prepared by me, I wish to add another section of the neighbourhood which still more convincingly shows—not only that since the early part of the tertiary period, the country, in some parts at least, has risen about 5,000 feet above the level of the sea, and after characteristic marine beds had been deposited—but also that many, even of the smaller deep gorges by which the mountain chains are traversed, were then already in existence. Judging from the different localities where similar beds are found, as for instance in Red Cliff on the southern banks of the Rakaia in a depression between Mount Hutt and the Palmer range—near the sources of the river Swin, whence a pass leads into the Northern Ashburton—these beds can be connected with those occurring at the Curiosity Shop, and on the banks of the river Wilberforce.

Before the river Smythe enters the Lake Heron plains, it has to run round a spur of the Palmer range, and it is here on the eastern side, that beds of old tertiary rocks reach to the very summit of that spur, whilst on the western or Lake Heron side they have been destroyed in the upper portion of the ridge without doubt by glacier action, once here so powerfully at work.

The lowest beds consist of—

1. Dark greyish sands with small seams or streaks of shaly coal, the planes of divisions sometimes covered with crystals of selenite, thickness variable from - - - - - - - - - - 30 to 60 feet.
2. They gradually alter to fine loose quartzose sands, generally white, sometimes with pinkish or salmon-coloured hues - - - - - - - - about 80 feet.
3. These are overlaid by dark brownish greensands, changing gradually to dark green tints containing *Pecten hochstetteri* and *Waldheimia lenticularis*, strike 170°, dip S. to E. 42° - - - - - about 40 feet.
4. They become more arenaceous, and then change into shell sands full of teeth of fishes, identical in character with the Trellissic series of the upper Waimakariri and containing *Turitella gigantea*, *Pectunculus laticostatus*, *Crassatella ponderosa*, *Cucullœa* - - - - - - - - about 35 feet.

5. These are capped by greyish sands, unfossiliferous, about twenty feet thick, and which have been preserved, from destruction by two beds of hard shell limestone, thickness about four feet, each divided by six feet of sands containing many of the Pareora fossils. Besides those already named as occurring in No. 4, I observed the large *Fusus spinosus* and several species of *Struthiolaria.*

On the western or Lake Heron side, the beds strike 60°, dip towards W.S.W. 46°; they are not of such great thickness, but otherwise identical in sequence and character.

There are no newer beds in this district except the morainic accumulations and the post-pliocene alluvium, and of which both maps and sections offer the necessary details.

NOTES TO ACCOMPANY A GEOLOGICAL MAP AND SECTIONS OF THE SHAG POINT DISTRICT, PROVINCE OF OTAGO.

BY JULIUS HAAST Ph.D., F.R.S.

21st February, 1873.

DURING an examination of the Shag Point coal measures in the autumn of last year, I had an opportunity of tracing the extent of the formation in which they occur, and of investigating the nature of the beds upon which they rest, as well as of those by which they are partially covered, thus giving me sufficient material to colour geologically a portion of the excellent lithographed map of the district (scale, one mile to one inch), which I obtained through the courtesy of the Chief Surveyor of Otago. A series of seven sections, which I add, will moreover enable the reader of these notes to understand more easily the sometimes complicated nature of the junction of the two conglomerate series, which in lithological character, as I shall show in the sequel, resemble each other in a very remarkable degree.

In looking at the general geological and topographical features of the eastern coast of this Island, we observe that during the cretaceo-tertiary epoch a large bay existed over an area of more than three and a-half degrees of latitude, from near the mouth of the river Waiau-ua, in the Province of Nelson, to south of Otago Peninsula, in which, during a long period of time, a variety of beds were formed, ranging from littoral to deep sea deposits.

Many localities where these beds occur have already been reported upon; I may here only instance those of the river Jed, in the Province of Nelson, of the Waipara, Malvern Hills, and Clent Hills, in the Province of Canterbury. I need scarcely add that the beds north of the Waiau-ua, as described by me in a former memoir, occurring at the Amuri Bluff, the Kaikoura Peninsula, etc., may possibly be the equivalents of the more southern formations in question, although we have been unable to discover in the latter any *Belemnites*, and the few other characteristic secondary fossils which are so abundant in the northern region.

The beds in which the Shag Point coal-measures occur are of purely littoral origin, and of enormous thickness; they are only portions of a larger formation, which, owing to many circumstances, has been destroyed over a great area, their place having often been taken by younger beds of similar nature. That portion which remains occurs in two patches, the larger or inland one being about seven miles long, and on the average two miles broad. The smaller or sea-side portion, in which the valuable Shag Point coal-measures are situated, is only one and a-half miles long and a quarter of a mile broad, as far as exposed for our examination.

METAMORPHIC ROCKS.

The older sedimentary metamorphosed rocks, which form the highest part of the Horse and Bush Reserve ranges, and upon which the older conglomerates repose directly, consist of a great variety of micaceous schists, some very quartzose, others very micaceous, striking generally from N.W. to S.E., and dipping towards the N.E. Amongst them, at the south-western boundary of the conglomerates, a considerable thickness of highly altered limestones appears; they occur as marbles of very light colours, mostly white, but too much jointed for building or ornamental purposes. They form however splendid material for the lime kiln, and when once proper railway communication is established will become of great practical value.

The calcareous beds occur also on both banks of the Marble Creek and in Mount Hart; they strike generally 252°, with a dip of 32° to

40° to the E.N.E. I did not observe these marbles on the eastern boundary of the metamorphic rocks, but the strike and dip of the micaceous schists in many localities closely agree with those above mentioned.

Farther to the north the schists stand at a much higher angle, as, for instance, in the range west of Otepopo, where I observed as high a dip as 81° to the S.W.

OLDER CONGLOMERATE OR SHAG POINT SERIES.

The lowest portion of the Shag Point series consists of detrital rocks, resembling in this respect the brecciated conglomerates of the Malvern Hills. They are formed of sub-angular or even angular pieces of micaceous schists, cemented together by an arenaceous matrix, and often appearing as a breccia. They were, doubtless formed in bays or along sheltered shores from the *dêbris* which fell from marine cliffs into the sea, or was brought down by small mountain torrents, becoming cemented together without being much affected by the waves and currents. Their strike and dip agree generally with those of the slopes of the ancient sea bottom, upon which they were formed, inclining at various angles from 8° to 55°.

Whilst in the eastern or younger portion in Mounts Iwitai and Vulcan, the beds reach an altitude of only 600 to 700 feet, at their western boundary they rise above 1000 feet. In some of their lowest beds we meet with small seams of brown coal, of which a section is visible near the summit of the road over the Horse range.

The lowest deposits which are here visible are light coloured shales, with bands of ferruginous sandstone and clay ironstone.

	Ft.	In.
In thickness ... ... about	16	0
Brown coal	1	2
Clay ironstone	0	8

covered by thick beds of conglomerates, consisting entirely of more or less angular pieces of micaceous schists ; but sometimes the place of the latter rock is taken by quartz, which often over a considerable area forms the whole mass of the conglomerate.

We have thus arrived at beds formed on the sea shore, where the power of the surf and of the waves was sufficient to grind down generally all the metamorphic rocks, pebbles of quartz only remaining, which offered more effectual resistance to the destructive agencies here at work.

Higher in the series the greater portion of the pebbles of which the conglomerate is composed consists again of micaceous schists, thus pointing to oscillations in the level of the lands or changes in the currents of the sea. Amongst other localities the sections in the Terapupu Valley prove this convincingly.

Here we meet in ascending order upon the quartz conglomerates in which small beds of shales occur—

		Ft.	In.
Brown coal of fine quality		0	4
Shales	about	10	0
Gritty sandstone, will be useful as building stone, (freestone)	„	15	0
Shales, total thickness	„	50	0
These latter beds are separated into several banks by 7 or 8 seams of excellent brown coal (pitchcoal), varying in thickness between 3 to 12 inches.			
Sandstone, gritty	about	12	0
Brown coal		0	6

The whole is capped by quartz conglomerates thirty to forty feet thick, with a few beds of ironstone between them. However, as in this part of the valley the hill sides consist of a succession of slips which hide a large portion of the beds, it may be possible that larger and workable seams do exist, which did not come within my observation, although I searched carefully over the ground.

I have alluded already in my first report to the Mount Iwitai beds, which are situated still higher in the series, consisting of thick deposits of conglomerate—between which layers of white quartzose sands often very incoherent are inter-stratified—and of shales. Amongst the latter a seam of fine pitchcoal of a thickness of three feet nine inches occurs, dipping at an angle of 64° to the E.S.E. Also here the conglomerates vary in their constituent parts, as some consist almost entirely of pebbles and boulders of quartz cemented by quartz sands, whilst others are a mixture of all the sedimentary and metamorphic rocks which, at the present time, form the shingle bed of the Shag River.

In crossing from here over to the smaller or Mount Vulcan area, and following a fine section along the northern bank of the Shag River, we pass in the lower portion through a whole series of conglomerates in which beds of shales with small seams of coal are inter-stratified.

About the middle of the section when the seams of coal begin to be more frequent we find—

		Ft.	In.
1.	Shales, with two bands of clay ironstone 1 foot 2 inches and 10 inches thick	about 21	0
2.	Pitchcoal	1	8
3.	Shales	7	6
4.	Pitchcoal 98°, dip 49° to S. by E.	0	7
5.	After a considerable thickness of conglomerate, follow, still in ascending order—		
6.	A seam of brown coal; thickness, several feet; but owing to slips could not be ascertained exactly.		
7.	Shales and coarse sandstone	about 50	0
8.	Pitchcoal	1	10
	This seam having been in combustion higher up on the hill sides, the rocks on both sides have been altered to porcelain jasper and other rocks of similar character.		
9.	Conglomerates and sandstones, with bands of shales inter-stratified	about 40	0
10.	Brown coal, 139° S.E. 39°	3	7
11.	Conglomerates, mostly quartz pebbles	about 20	0
12.	Shales	„ 12	0
13.	Pitchcoal, 136° S.E. 31°	5	1
14.	Shales	4	0
15.	Coal, shaly	3	6
16.	Coal, visible	about 4	0
	Nos. 15 and 16 appear to belong to one seam.		
17.	Ground covered by slips, but containing also coal	„ 10	0
18.	Coal, visible	6	6
	This seam is sub-divided by several layers of shaly coal.		
19.	Shales and coal sandstone (grit) 132° S.E. 24°	about 10	0
20.	Conglomerate	„ 20	0
21.	White incoherent sands	„ 14	0
22.	Conglomerate	„ 18	0
	The latter assuming here a very ferruginous (limonitic) character from long exposure to disintegrating agencies.		

It will be seen from the details of this section, of which No. 1 gives the general outlines, that this formation, principally in its upper portion, contains valuable seams of pitchcoal, of which 13 to 16 might represent the beds exposed in the Shag Point coal mine, where the mining works have made us acquainted with the following beds, in a descending order:—

		Ft.	In.
Shales (thickness unknown)			
Pitchcoal - - - - - - - - -	thickness,	3	10
Shales - - - - - - - - -	„	4	4
Pitchcoal - - - - - - - - -	„	1	4
Fire clay - - - - - - - - -	„	0	6
Pitchcoal, main seam - - - - - -	„	8	0
The only one at present worked, strike 217°, dip 16° to N.E.			
Shales (thickness unknown).			

Moreover, the section at the mouth of the Shag River shows convincingly that, besides the two workable seams known to exist in the mine, there are several more which will be available if the demand for coal increases in the district.

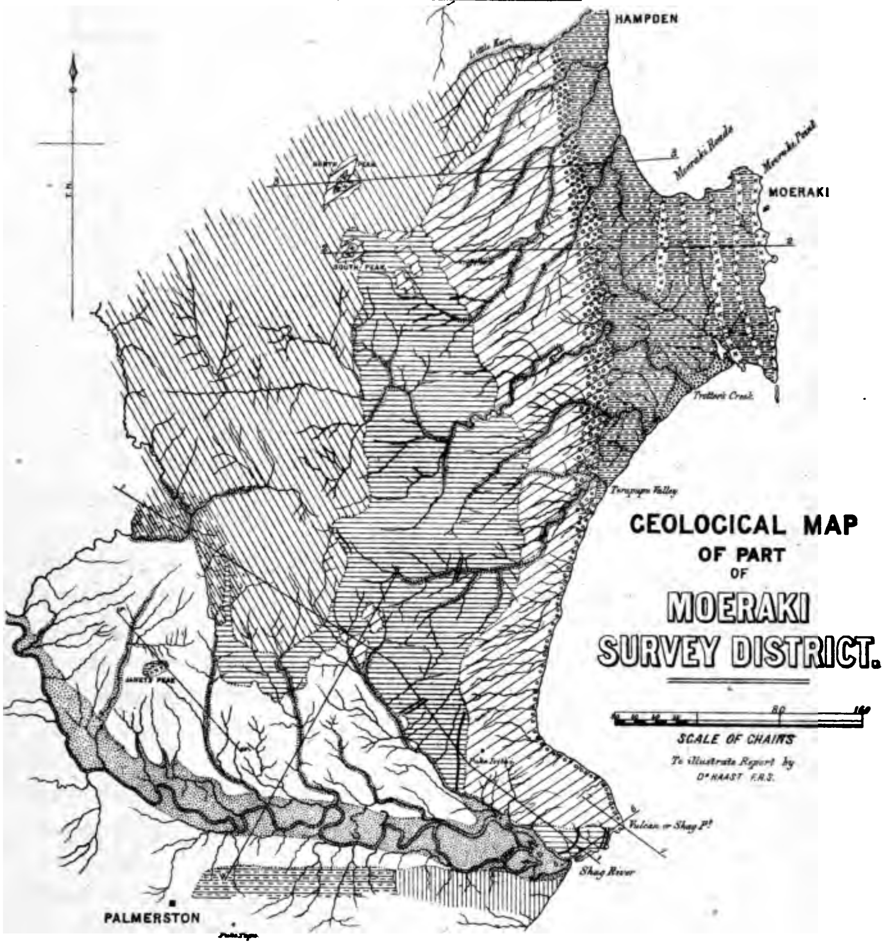
The section No. 1 proves also clearly that the whole of the beds are of the same character and are of enormous thickness, representing a long period of time during which the same geological conditions were existing. Moreover, the sandstones, shales, and ironstones throughout the whole series contain numerous remains of plants, mostly dicotyledonous leaves, ferns, and a few conifers, belonging to the same species throughout the whole beds.

No fossil animal exuviæ were found by me which would enable us to compare them with formations occupying a similar stratigraphical position in the northern portion of the large bay previously alluded to. Fortunately, besides a few dicotyledonous leaves, there occurs a fossil plant, consisting of leaves and twigs allied to *Dammara*, which is identical with a species obtained at the Waipara, where it is sometimes enclosed, either alone or together with Saurian remains, in the huge *Septaria*, which are so characteristic of that horizon.

YOUNGER CONGLOMERATE AND SEPTARIA FORMATION.

After the deposition of the coal-bearing beds described in the foregoing part, it appears that they were subjected to enormous

GEOLOGICAL SURVEY OF NEW ZEALAND.



GEOLOGICAL MAP OF PART OF MOERAKI SURVEY DISTRICT.

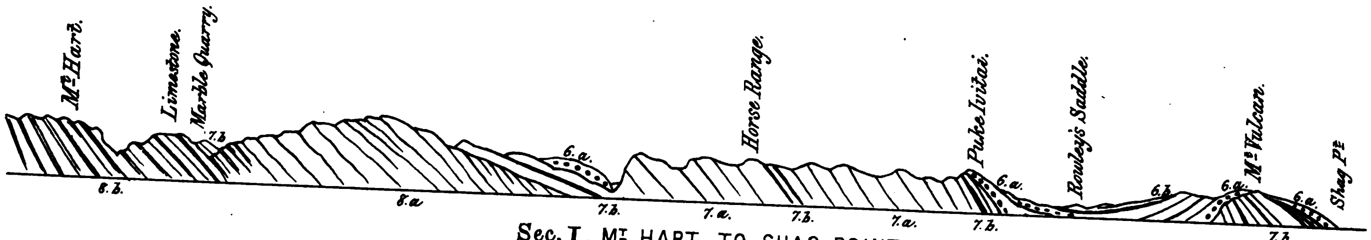
SCALE OF CHAINS

To illustrate Report by
Dr HAAST F.R.S.

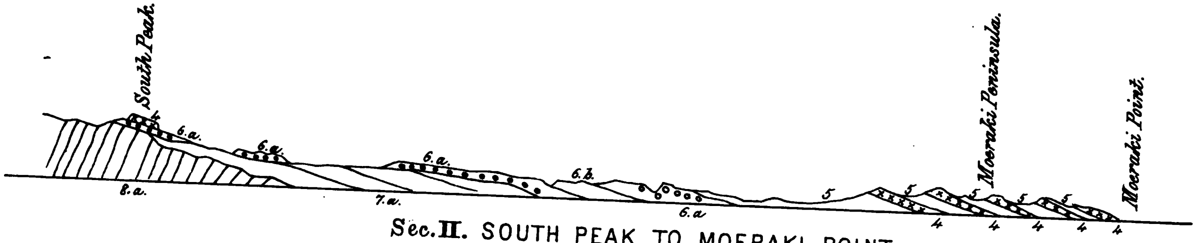
REFERENCE

- I ▨ a. Driftsands. b. Recent Alluviums.
- II ☐ Lacustrine Deposits.
- III ▥ Arenaceous & Calcareous beds, (middle tertiary)
- IV ×××× Basalts.
- V ▤ Greensands
- VI ▨ a. Septaria beds. b. Clay-marls (older tertiary)
- VII ▤ a. Conglomerates, Ferruginous Sandstones & Shales, (Cretaceo-Tertiary) b. Coal seams.
- VIII ▧ a. Micaceous Schists. b. Marble.

J. Buchanan del.

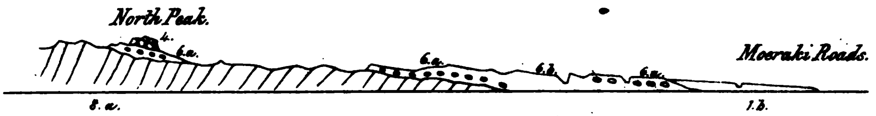


Sec. I. Mt HART, TO SHAG POINT.
N. 58 W. to S. 58 E.



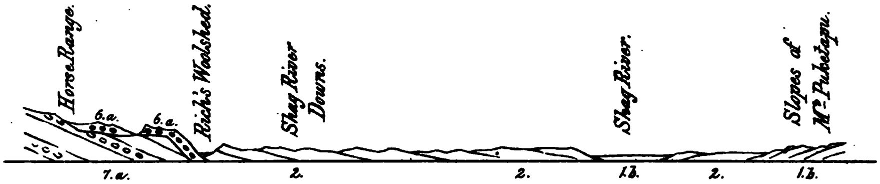
Sec. II. SOUTH PEAK, TO MOERAKI POINT.
W. to E.
Scale, 5280 to one inch, Hor. & Vert.

J.B. lith.



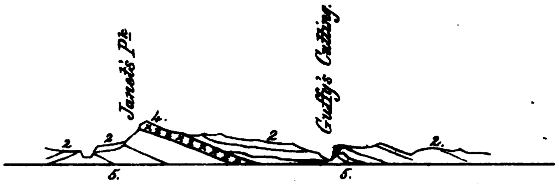
Sec. III. NORTH PEAK, TO MOERAKI ROADS.

S. 85 W. to N. 85 E.



Sec. IV. HORSE RANGE, TO NORTHERN SPUR OF PUKETAPU.

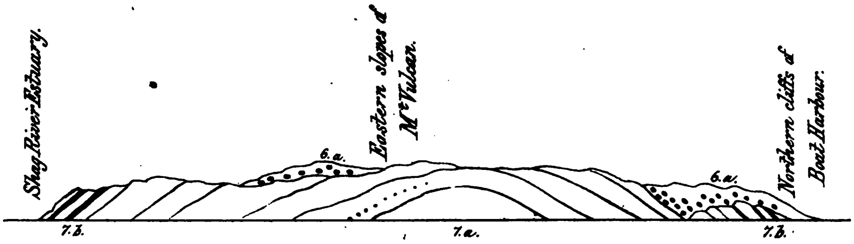
N. 35 E. to S. 35 W.



Sec. V. SHAG RIVER DOWNS WITH JANET'S PEAK.

N. 45 W. to S. 45 W.

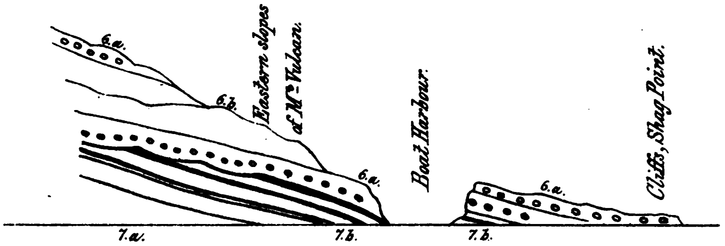
Scale, 5280 ft. to one inch, Hor. & Vert.


Shag River Estuary.
6.a.
Eastern slopes of Mt. Vulcan.
6.a.
Northern cliffs of Boat Harbour.
7.b.
7.a.
7.b.

Sec. VI. SHAG RIVER ESTUARY, TO SHAG POINT.

S. 50 W. to N. 50 E.

Scale, 5280 ft. to one inch, Hor. & Vert.



Sec. VII. AT THE BOAT HARBOUR, SHAG POINT.

Scale, 100 ft. to one inch, Hor. & Vert.

J.B. lith.

denudations which occurred principally to the north and south along two drainage channels, formed on the one side by the Little Kuri and similar small streams, and on the other by the Shag River. Thus the beds were destroyed all along the line where now the valley of the Shag River exists, whilst in the north the denudation owing to the existence of smaller watercourses was only on a minor scale. To judge from the results of that denudation, it is evident that it was mostly of sub-aerial character, assisted in the latter part by littoral agencies. The country sinking again, during and after this denudation had taken place, to or below the sea-level, beds of similar lithological character, as far as their lower portion is concerned, were deposited above or on the flanks of the remnants of the older strata, consisting of conglomerates, ferruginous sandstones, altering to *Septaria* clays, which were again covered by sandy beds becoming gradually glauconitic. As some of the newer conglomerates are similar in their constituents to the older ones, and moreover are often deposited upon them in an apparently conformable position, so that they might be mistaken for their sequence (unconformable sequence), some difficulty was experienced by me in several places before I could understand the real position of each.

In some localities, as for instance on the southern side of the Shag River, near Palmerston, also near the Otepopo River, seams of brown coal are associated with the lowest beds of this younger series. In their turn, these newer conglomerates once covered the whole lower country, but they also underwent great denudations, as the few patches in the ranges and in some lower localities show where they have been preserved by favourable circumstances. Thus for instance, at the North and South Peaks, a stream of basaltic lava has flowed over them, or near Rich's wool-shed, in the valley of the Shag River, where they were deposited in a bay-like depression upon the older conglomerates (see sections 2, 3, and 4); also at the boat-harbour, and thence to the mouth of the Shag River some interesting sections are easily accessible, showing the unconformity of both sets of beds.

I was unable to discover any fossils in these beds, and also an examination of the *Septaria* (the so-called Moeraki boulders) did not give any results, only minute portions of plants appearing to form the centre of the concretions could be discerned in or near the centre of the *Septaria*.

GREENSANDS AND BASALTS.

Above the *Septaria* beds follows a great thickness of more or less glauconitic deposits during the formation of which eruptions of basaltic rocks took place repeatedly, which in the Moeraki Peninsula can be well studied, and where the volcanic streams have altered, in several localities, the sandy beds near them to porcelain jasper and rocks of similar character. Basaltic tufas are also associated with them.

CALCAREOUS SERIES.

These greensands are overlaid again by a series of sandy clays with bands of calcareous rock between them, the whole having a ribboned appearance; the sandy beds being three to five feet, and the calcareous one and a-half to two feet thick, the latter forming protuberances.

In them occur fossils, but mostly in a fragmentary state. However, I was able to recognize the following genera or species :—

Crassatella, Scalaria, Ostrea (small white), *Pectunculus laticostatus, Turbinolia.*

These beds occur only on the southern banks of the Shag River, forming cliffs along the sea coast for a considerable distance.

LACUSTRINE DEPOSITS.

Finally, in the broad valley of the Shag River, occurs a series of micaceous sandy shales, forming small hills. These peculiar soft rocks fall generally at a low angle, and have light pinkish or yellowish colours. They have the appearance of lacustrine deposits, but might possibly be estuary beds. They are amongst many localities well exposed in Guffie's Cutting (section No. 5), between Janet's Peak and Palmerston.

REPORT ON THE GEOLOGY OF THE NORTH-EAST PORTION OF THE SOUTH ISLAND, FROM COOK STRAITS TO THE RAKAIA.

By Capt. F. W. HUTTON, F.G.S.,
Assistant Geologist.

7th April, 1873.

Narrative of Exploration.

I left Wellington on the 2nd December, 1872, and arrived at Nelson the next day. I spent the following morning in examining the Port Hills and Arrow Rock, and in the afternoon proceeded to Foxton. The next day I went to Rotoiti Lake, and on the 6th through the Wairau Gorge to Tarndale, and on the 7th by Maling's Pass to Mr. W. T. L. Travers' station at Lake Guyon. Here I remained until the 12th examining the surounding country, and on the 13th went by Fowler's and Jack's Passes to the Hanmer plains. On the 14th I went to the Hurunui township, and on the 15th to Mr. Shrimpton's on the north-west side of the Hurunui plains. The next day I went to Mr. Macrae's station at Mandamus, and from that by the Upper Pahau, Culverden, and St. Leonards, to Cheviot Hills, which I reached on the 20th. On the 21st, after examining Gore Bay, I went to Parnassus, and then by the Wairau township and Lyndon, to Highfield, which I reached on the 24th. On the 26th I went by Mount Cookson and the Whale-back into the Upper Conway, and the next day reached Amuri Bluff. On the 29th I went to Kaikoura Peninsula, and remained there until the 2nd January, 1873, examining the country. I then proceeded up the coast to Flaxbourne, Cape Campbell, and Starborough, and reached Blenheim on the 10th. The next day I went to Picton, and remained there two days, examining the country, and on the evening of the 13th left by steamer for Wellington.

On the 28th January, 1873, I again left Wellington, and arrived at Christchurch the next day. On the 31st I rode to Leithfield, and the next day by Glenmark to Mr. Sanderson's station on the Waikari. On February 3rd I went to Motanau, and on the following day to Stonyhurst. I remained here a couple of days, examining the country towards the Hurunui, and then went *viâ* the Waikari to the Weka Pass, which I reached on the 7th. I remained here a day examining the country, and on the 9th I went on to Horsely Downs on the

Waitohi. On the 10th I went down the Waipara by Heathstock, to Boby Creek, and the next afternoon I went to Leithfield. I then went by Oxford to Mr. J. McIlraith's station, of Homebush, on the Malvern Hills, which I reached on the 13th. On the 14th I went up the Selwyn, and crossed over by Mount Misery to Rockwood. The next day I went to Mr. Oakden's station on Lake Coleridge, where I remained a day, and then went up the Acheron to Mr. Enys' station, Castle Hill, on Broken River, and back by Porter's Pass to Christchurch, which I reached on the 20th. On the 21st I went with Dr. Haast to the head of Governor Bay, on Banks Peninsula, and left for Wellington on the 22nd.

In addition to this excursion, I have also twice before visited Nelson, and examined the Brook Street and Maitai Valleys, and the coast towards Wakapuaka.

It will be noticed that there are three large portions of the district that I have not examined. The first is between Nelson and the Wairau, and about Pelorus Sound. Dr. Hector, however, has examined this district, and I have availed myself of his section, published in the Geological Reports, 1871–72, p. 122, in compiling the map that accompanies this Report. The other two districts are the country between the Wairau and the Kaikouras, and that from the Mytholm Mountains southwards to Mount Torlesse. Both these districts are very mountainous, and show no promise of any important geological information being obtained in them until the topographical maps are sufficiently improved to allow the boundaries of the older formations to be worked out, while the chief object of my excursion was to make out the relations of the different tertiary and upper secondary formations. More information on many parts of the district will be found in the following reports, etc., which have been already published, and although it will be noticed that my opinion differs considerably from some of those expressed in these reports, I wish to acknowledge the great assistance they have been to me in directing my attention to localities which would otherwise have escaped me, and more particularly am I indebted to the collections of fossils made by other observers, without a previous study of which I should have had far more difficulty in making out the general geological structure of the district. I have also found the tables of altitudes, given by Dr. Haast in his various reports, of great assistance in studying the post-glacier deposits.

List of Papers referred to.

Marlborough and Eastern Nelson (Dr. Hector)—Progress Report, 1866–7, p. 17.
Marlborough and Eastern Nelson (Dr. Hector)—Geol. Reports, 1871–2, p. 119.
Nelson district (Mr. Davis)—Geol. Reports, 1870–1, p. 103.
Nelson district (Mr. W. Travers)—Q. J. Geol. Soc., 1866, p. 254.
Kaikoura district, etc. (Mr. Buchanan) —Geol. Reports, 1866–7, p. 34.
Amuri district, etc. (Dr. Haast)—Geol. Reports, 1870–1, p. 25.
Waipara district (Dr. Hector)—Geol. Reports, 1868–9, p. x.
Waipara district (Dr. Haast)—Geol. Reports, 1870–1, p. 5.
Waipara district (Dr. Haast)—Trans. N. Z. Inst., II., p. 186.
Glentui district (Dr. Haast)—Geol. Reports, 1871–2, p. 85.
Malvern Hills district (Dr. Hector)—Geol. Reports, 1870–1, p. 46.
Malvern Hills district (Dr. Haast)—Geol. Reports, 1870–1, p. 135.
Malvern Hills district (Dr. Haast)—Geol. Reports, 1871–2, p. 1.
Hanmer Plains (Dr. Haast)—Trans. N. Z. Inst., III., p. 293.
Hanmer Plains (Dr. Hector)—Trans. N. Z. Inst., III., p. 297.

Description of the District.

The district that I examined extends from Cook Straits, between Nelson and Cape Campbell, to the river Rakaia, from Banks Peninsula to Lake Coleridge; being 200 miles in length by about 55 in breadth, or a superficial extent of about 11,000 square miles. The greater part of the country is excessively mountainous, but passes into low hills between the lower Awatere and Flaxbourne; from the lower Waiau-ua southwards, through the Cheviot Hills to the Canterbury plains, and along the north-west border of the Hurunui plains; the only flat land of any consequence being the northern part of the Canterbury plains from the Waipara to the Rakaia, the Kaikoura plains, the Wairau plains, and the Waimea plains near Nelson, all of which are bounded on one side by the sea, and the Hurunui and Hanmer plains, which are situated inland and bounded on all sides by mountains or high hills.

The mountain ranges have a general north-east and south-west trend, and in the central part of the district are cut through by the rivers Conway, Waiau-ua, Hurunui, Waipara, Waimakariri, and Rakaia; while in the northern part of the district the rivers Clarence, Awatere, and Wairau run parallel with the main ranges, or in a north-east direction.

General Geological Structure of the District.

A broad band of palæozoic rocks runs obliquely through the district in a north-east and south-west direction from the upper Rakaia to Cook Straits, forming generally high ranges of mountains often covered with perpetual snow. Flanking this range—on the south-east from the Malvern Hills to Cape Campbell, and on the north-west from Tophouse to D'Urville Island—is a large development of secondary rocks, which, although never attaining the same height as the central chain, often forms mountains of considerable elevation. Flanking these again, and penetrating into the valleys of the secondary ranges, especially between the Conway and the Waipara, tertiary formations are found generally forming rolling downs, while in a few cases outliers of tertiary, and even upper secondary, rocks are found in the valleys of the palæozoic mountains.

Volcanic rocks of different ages are found in the south at Banks Peninsula, the Malvern Hills, the Acheron, and Broken River; in the centre of the district on the north-west side of the Hurunui plain; and in the north near Nelson.

The following table shows the way in which I propose to divide the rocks found in this district:—

Probable Age.	Formations.
Pleistocene and Newer Pliocene	Post-glacier deposits (*a*).
Older Pliocene - -	Glacier deposits (*b*).
Upper Miocene - -	Pareora formation *Awatere group (*c*). †Kanieri group (*d*).
Lower Miocene - -	Ahuriri formation (*e*).
Upper Eocene - -	Oamaru formation *Trelissic group (*f*). Ototara group (*g*).
Upper Cretaceous -	Waipara formation Amuri limestone (*h*). *†Ngarara group (*i*).
Mid Jurassic - -	†Putataka formation (*k*).
Lower Jurassic -	*Maitai formation (*l*).
Upper Triassic - -	Wairoa formation (*m*).
Upper Palæozoic -	Kaikoura formation (*n*). Tuamarina formation (*o*).

The letters (*a*), etc., refer to the sections.

* Contemporaneous volcanic rocks are found in these groups.

† Coal is found in these groups.

Large breaks in the sequence occur between the Oamaru and Waipara formations, between the Waipara and Putataka formations, and between the Wairoa and Kaikoura formations; while the tertiary rocks follow one another in tolerably regular succession from the Awatere group to the Ototara group; the Ahuriri formation, however, being often absent. The accompanying map and sections show these unconformities, but the divisions on the map between the older formations have no pretension to strict accuracy, more especially the line between the Putataka and Maitai formations. I think, however, that they will be found to fairly represent the general geological structure of the district; it will take years of labour with far better maps than we now possess to work out the boundaries correctly. The tertiary and upper secondary (Waipara) formations are more accurately laid down, for it was to them that my attention was more particularly directed, but even here many alterations and improvements will, I have no doubt, eventually be made, particularly in the broken country between the Clarence and Cape Campbell, and in the Mount Cass Range between Motanau and the mouth of the Waipara.

TUAMARINA FORMATION.

This formation occupies the whole of the Queen Charlotte Sound district, from Port Underwood to the Pelorus, and extends for some distance up the north-west side of the Wairau, but I did not ascertain the exact position of its western boundary, where it is overlaid unconformably by the Maitai formation. It again occurs at Cannibal Gorge, on the western side of the Spenser Mountains, where it can be seen to underlie the vast masses of sandstone which form the principal part of that range.

The strike of the beds between the Wairau and Picton is N.N.E., getting to a northerly direction on the west side of Queen Charlotte Sound. Near Massacre Hill the dip is 45° E.S.E., and this direction of dip continues nearly to Picton, when an anticlinal is passed and the dip changes to 75° W.N.W. On the west side of the bay it is 80° W. In Cannibal Gorge the dip is 55° S.E. On the western side of the Spenser Mountains this formation consists of phyllites, quartzites, and occasional beds of chlorite schist; while at Picton sandstones and conglomerates are in places interbedded with phyllites and quartzites. At about two miles from Picton, in a cutting on the north side of the Blenheim road, fossils occur in a blue argillaceous sandstone dipping

75° W.N.W. and covered by a conglomerate containing pebbles of quartzite and diorite. The fossils are obscure, and difficult to indentify, but among them appear to be *Orthoceras*, *Phragmoceras?* and a small species of *Thracia* or *Anatina;* at any rate they are quite different from any others in the Colonial Museum.

This formation is, I think, younger than the mica-schists of Lake Wakatipu (Geol. Reports, 1871–2, p. 99), for the metamorphic action has been so very much less, and I consider that it should be grouped with the phyllites of Athol (Geol. Reports, 1871–2, p. 101). The clay slates and felspathic slates of the Aorere and Slate River (Geol. Reports, 1870–1, p. 151) are also probably of the same age.

KAIKOURA FORMATION.

This formation occupies about one-half of the district under review, extending uninterruptedly in a north-east and south-west direction from Cook Straits to Lake Coleridge on the Rakaia, a distance of 180 miles, and having its greatest breadth between the Wairau and the Kaikoura Mountains, a distance of 50 miles. The general strike is N.E., but locally it varies very much, and the formation, which must be of immense thickness, does not appear to me to be thrown into parallel folds but into huge domes and cup-shaped depressions. Such at least is, to the best of my judgment, the structure of the Spenser Mountains, but I cannot speak as to the country between them and the Kaikouras, nor about the Kaikouras themselves.

The rocks are principally grey and dark-green sandstones, with numerous small quartz veins; fine grey argillaceous sandstone; conglomerate; grey argillite; clay slate; and purple jasperoid slates passing into quartz-rock. This latter is found in the Spenser Mountains; at St. James, near the easterly bend of the Clerence; on the Hanmer Plains, at the foot of Jack's Pass; at Mount Torlesse and the surounding districts; and at Taylor Pass, near the mouth of the Awatere. The grey sandstone with quartz veins extends from the Rakaia through the Spenser Mountains to Lake Rotoiti, and eastward to the Wairau Gorge and north side of the Hanmer Plains, but I did not notice it in the Kaikoura Mountains.

As the larger part of this formation consists of thick beds of sandstone, the disturbances do not often appear to be great, but where they are more thinly bedded, and their structure can be made out, they display great contortions and crumplings. The beds at Porter's Pass, for instance, are gnarled and twisted in an extraordinary manner, although these distortions but little affect the general dip. The general colour of these rocks is grey, but in places the *débris* from the jasperoid slates tints the grey shingle slopes with the most lovely shades of rose and purple.

In the Spenser Mountains, this formation appears to lie conformably on the Tuamarina formation (Section i). Near Blenheim, the junction of the two is covered up by alluvium, but there is no reason for suspecting an unconformity to exist there either.

The only fossils that have been as yet found in this formation are the so called "markings or obscure exuviæ of an Annelid," obtained by Dr. Haast at Mount Torlesse and other places (Geol. Reports, 1871–72, p. 5), and probably also a coral which I found at the north point of Harataonga Bay, in the Great Barrier Island. We have therefore no hopes at present of determining its age.

WAIROÀ FORMATION.

This formation occurs in this district only near Nelson, forming a narrow strip of low hills on each side of the débouchure of the Wairoa, called the Richmond Hills, in which *Monotis salinaria* var. *richmondiana*, *Halobia lomelli*, and *Mytilus problematicus* are found. The rocks are similar to those of Southland, which contain the same fossils (Geol. Reports, 1871-72. p. 103).

MAITAI FORMATION.

The principal mass of this formation is found near Nelson, extending from the Top-house on the Upper Wairau to D'Urville Island. Another large portion extends from the Malvern Hills to Mount Grey and the Waipara. It then skirts along the eastern border of the Kaikoura formation as far as the Hanmer Plains, where for a short distance it disappears, and appears again on the north-east side of the plains, from whence it extends to Amuri Bluff, and the Kahutara River, divided into two portions, however, at the Whale-back by tertiary rocks. From Amuri Bluff, a spur goes southwards as far as the river Jed; and a large outlier occurs to the north between the Kaikoura Plains and the Clarence, detached from the Kaikoura formation by a narrow belt of upper cretaceous limestone. Other small outliers are found in the View Hills, on the Waimakariri, and on Banks Peninsula at the head of Governor Bay.

The rocks of which this formation is composed are dark grey and green sandstones; green and dark blue slates; greenstone tuff; and conglomerates, often containing large quantities of pebbles of jasper. The bedding is thinner and generally much more easily distinguished than it is in the Kaikoura formation, consequently they appear to be more contorted, though in reality they are not so. I could not find any junction of the two formations clearly displayed, but nevertheless complete unconformity exists between them, for from Pelorus Sound to the Upper Wairau, this formation rests partly on the Tuamarina and partly on the Kaikoura formation.

I found no fossils in these rocks, except obscure traces of plants in the Mandamus, some of which appeared to belong to a small species of *Tæniopteris* with rather distant parallel serration. Near Nelson however, in the valley of the Wairoa and on the slopes of the Dun Mountain, Dr. Hector obtained *Inoceramus*, *Mytilus*, and *Spirifera*, thus showing a probable liassic age for these beds. The same *Spirifera* is also found in the Upper Otapiri and at the Nuggets and Roaring Bay in Otago, and at Mount Potts in Canterbury; and this formation no doubt occurs at all these places.

Contemporaneous Volcanic Rocks.—Interbedded volcanic rocks are found in this formation at the Malvern Hills; the Mandamus River, in the N.W. corner of the Hurunui Plains; and near Nelson. In the Mandamus they occur in a particularly instructive manner, as that river has cut through the neck of the old volcano and exposed a very interesting section. The neck of the volcano is filled with syenite (Sec. ii., *t*) composed of white, or sometimes reddish felspar with black crystals of hornblende. It dips to the E.S.E., at an angle apparently of 45°, but the only section, up Coal Creek, where the actual junction of the syenite with the slates can be seen is too small to trust to. That it dips to the E.S.E. is shown by its exposure on the surface, where it forms an oval of which the major axis runs in an E.S.E. and W.N.W., direction, and of which the Hurunui peak forms the eastern extremity. The slates are much altered at their junction with the syenite, and have an irregular cleavage parallel to the neck.

Higher up the river, near the Dove (incorrectly called the "Dora" in Stanford's map), a thick mass of volcanic agglomerate is seen interbedded with the slates (Sec ii., *t′*), thus proving the date of the volcanic eruptions. This agglomerate consists entirely of angular and sub-angular volcanic rocks, none of which quite resemble the syenite of the neck. Most of the blocks are either a porphyrite, or a kind of diorite with crystals of hornblende in a fine felspathic paste, but small quantities of scoriæ also occur, the whole being cemented together by a felspathic and sandy matrix.

Another good section (Sec. iii.) is also obtained up a small creek that runs into the Mandamus from the west, just opposite to the Dove. Here we see three separate lava streams (Sec. iii., *t″*) of vesicular basalt, or anamesite, dipping 75° W. by S., parallel to the bedding of the sedimentary rocks. The first of these is five feet, the next three feet, and the third ten feet in thickness. These lava flows are fine grained and full of small vesicles, many of which are now filled up with a white mineral. Their structure indicates that they were probably sub-marine. Higher up the creek we find a broad dyke of porphyrite (Sec. iii., *t‴*) cutting across the strata and dipping about 30° W.S.W.

The evidence is therefore complete as to the age of the volcanic eruptions, and the question naturally arises, is the syenite of the neck in the same state now as when it was erupted? Without pretending to give a definite answer to this question, I may point out that the rocks in the agglomerate differ in texture from the syenite, and that in the centre of the neck several dykes of dark coloured basalt or anamesite, similar to that of the lava flows, but without the vesicles, are found (see Dr. Haast's Sec. xxvii., Geological Reports, 1870–71, p. 46). From their fantastic shapes, and from their sometimes shading off imperceptibly into the syenite, I consider that these dykes have not been caused by injection, but by segregation, or possibly they may represent the original structure of the neck, having for some reason or other resisted the metamorphism that has changed the rest into syenite. Be this as it may, there can be no doubt that a study of the volcanic rocks in the Mandamus would lead to very interesting results.

Near Nelson, large beds of greenstone breccia, interbedded with the Maitai slates, extend from the syenite of the Wakapuaka as far as Brook-street Valley; and the serpentine of the Dun Mountain is probably an altered syenite or diorite of the same age.

The centre of eruption of the greenstone tuffs of the Malvern Hills has not yet been discovered.

Putataka Formation.

In the absence of fossils it is very difficult to ascertain the limits of this formation in the district under review, and, except in the Malvern

Hills, I have been compelled to depend entirely upon lithological characters for dividing this from the Maitai formation, a very unsatisfactory test when the rocks of each present so much similarity. In the Cairn Range, and at the eastern foot of the Flag-pole Hill, in the Malvern Hills, however, *Polypodium hochstetteri* and a species of *Tæniopteris*, identical with one found near Port Waikato, and at the Mataura, occur associated with a series of rocks which can be distinguished from the Maitai formation, and which also occupy a considerable extent of country between the Waipara and the Hanmer Plains, composing the Doctor's Hills, Black Hills, Laurie Peaks, and other small ranges between these and the sea. They are also found on the north-west side of the Hurunui Plains, from Balmoral to the Leslie Peaks, and again at Mount Parnassus, and form a small outlier behind the Amuri Bluff Hill. These rocks I consider to be the equivalents of the Putataka beds at Port Waikato (Geol. of Lower Waikato, 1867, p. 3), and the sandstones, etc., with ferns and *Astarte wollumbilläensis* which occupy the country from the Hokanui Hills to Waikawa, in Otago (Geol. Reports, 1871–72, p. 104), forming the Mataura series of Dr. Hector.

In the present district the rocks consist of green sandstones and shaly slates, but I could detect no fossils in them except obscure plant remains near the Hurunui Bridge. They are quite as much folded as the rocks of the Maitai formation, and I could trace no signs of unconformity between the two.

Small seams of coal are found in this formation near the Amuri Bluff.

WAIPARA FORMATION.

The only two districts in which this formation covers a considerable extent of country, are from near Cape Campbell along the eastern base of the Kaikoura and Looker-on Mountains as far as Kaikoura Peninsula and the Kahutara River, and also along the eastern and southern borders of the Malvern Hills, extending up the left bank of the Rakaia as far as Lake Coleridge. Other isolated patches are found at Amuri Bluff; at the mouth of the Conway, and also about ten miles up that river; on the river Jed; from the mouth of the Blyth, by Stonyhurst to Mount Cass, near the mouth of the Waipara; on the south slope of the Black Hills; from the northern part of the Weka Pass across to the limestone gorge of the Waipara and Boby Creek; at Heathstock on the Upper Waipara; at Glentui on the Ashley; at the Burnt Hills near the Waimakariri Gorge; and between Castle Hill and Craigie Burn on the Broken River.

The occurrence of the outliers in the Upper Waipara, Broken River, and Rakaia, are very interesting, for they prove that many of our valleys were formed during the lower cretaceous period, for no such outliers of jurassic rocks can be found.

This formation rests quite unconformably on the older formations (Secs. v., vii., ix., x., xi.), lying indifferently on the Putataka, Maitai, and Kaikoura formations. North of Amuri Bluff, it has been considerably disturbed, and the upper limestone is sometimes corrugated, but I saw contortions in one locality only—the middle Conway (Sec. iv.), and they are only quite local. South of Amuri the disturbance has been much less, and at the Malvern Hills the beds usually dip at low angles for considerable distances. An exception, however, occurs on the southern and western sides of the Rockwood Hills, where the bedding has suffered considerable derangement. The formation can be divided into two portions, for the lower of which I propose the term Ngarara* group, as it is from this horizon that all the Saurian remains as yet obtained in New Zealand have come. The upper I shall call the Amuri limestone.

Ngarara Group.—This group of beds consists of grey shales, and grey or green, often very soft sandstones, which contain in places calcareous concretions, while in the north, at Flaxbourne, the upper part passes into a calcareous sandstone (Sec. viii., *i'*). Near the base of the formation beds of both brown and black coal occur at the Malvern Hills, and thin seams of brown coal have also been found in the Waipara.

These beds contain in places abundance of fossil Mollusca belonging to the genera *Belemnites* (2 sp.), *Aporrhais*, *Myacites*, *Panopœa*, *Cytherea*, *Dosinia*, *Cardium*, *Venericardia*, *Mytilus*, *Trigonia*, *Arca*, *Pecten*, *and Ostrea*. In addition to these we find *Conchothyra parasitica*, McCoy† (M.SS. ?), *Dentalium majus*, Sowerby, originally described from the tertiary beds of Chili; *Lucina americana*, Sow., originally described from the jurassic rocks of Peru; *Cucullœa alta*, Sow., originally described from the tertiary beds of Patagonia, and found also in our miocene and eocene rocks ; *Cucullæa ponderosa*, Hutton, which occurs in our lower miocene beds ; and *Inoceramus haasti*, Hochst., found also at Kawhia associated with *Ammonites novo-zealandicus*, Hauer, and *Belemnites aucklandicus* var. *minor*, Hauer, in beds of uncertain age.*

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* *Ngarara*, a reptile.

† *Conchothyra* is allied to *Struthiolaria*. The shell is at first spiral, afterwards convolute; the inner lip has a strong callosity which extends over the anterior end of the aperture; the right lip is expanded, sinuated, and recurved, forming a thick callus which joins that of the inner lip. In old individuals this callus entirely envelopes the whole shell.

Of these the species of *Trigonia* is found both at Amuri and the Waipara, and the *Cytherea* and *Dosinia* at Amuri and the Malvern Hills ; while *Conchothyra parasitica*, the *Myacites*, and *Ostrea* are found both at Waipara and the Malvern Hills. The concretions in the sandstones often contain large quantities of Saurian bones, *Plesiosaurus australis*, *P. hoodi*, *P. crassicostatus*, of Owen (Geol. Mag., 1870, p 49), and other genera. These concretions are undoubtedly *in situ*, for they occasionally contain shells (*Aporrhais*, *Cucullæa*, etc.) of the same species that are found in other beds of the same formation, and their shape is quite different to that of rolled boulders. That fragments of bone are sometimes exposed on their surfaces is no argument against their concretionary nature, for it only shows that the concretionary structure had not proceeded far enough to include the whole of the bones, and I am not aware that any true waterworn surfaces of exposed bones have been observed in concretions in place, although, of course, they are very likely to occur after the boulders have fallen into the creek (see Geol. Reports, 1870–1, p. 11, note).† Dr. Haast also obtained the paddle and other bones of a *Plesiosaurus (?)* out of the sandstone itself on the banks of the River Jed. Leaves of *Dammara* and dicotyledonous plants, as well as branches and cones of pines, are also found in the lower parts of the formation, but they have not yet been described. While, therefore, the Saurians, *Belemnites*, *Myacites*, *Lucina americana*, and *Inoceramus haasti* indicate the mesozoic age of this formation, the occurrence of *Dosinia*, *Dentalium majus*, the two species of *Cucullæa*, and dicotyledonous leaves, indicate that it belongs to quite the uppermost part of that epoch, and it can, I think, therefore be referred with tolerable confidence to the upper cretaceous period.

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* In a paper read before the Geological Society of London on the 12th March, 1873, I stated that *Rhynchonella nigricans* and *Waldheimia patagonica* occurred in this formation. This is a mistake, for both species come from the Culverden beds, which I now refer to the Oamaru period. The same remark applies to the cretaceous Echinodermata mentioned in that paper, all of which come from the Cobden limestone, which I now also refer to the Oamaru formation.

† Mr. Alexander McKay, who has lately collected a large quantity of fossils from Amuri Bluff for Dr. Hector, informs me that at that place some of the concretions containing Saurian bones are distinctly stratified, and that the planes of stratification in them lie parallel to the bedding of the rocks in which they occur, and that the same species of *Pecten* (*P. obovatus*, Stol. ?) is found both in the concretions themselves and in the beds above and below them.

Amuri Limestone.—This consists of a white, or pale grey, argillaceous limestone, always in thin beds, which are often much broken up. North of Amuri Bluff, and at Kaikoura Peninsula, it contains layers and nodules of yellow and grey chert often passing into flint, but never black like the chalk flints of England. It appears to rest quite conformably on the Ngarara group, but overlaps it considerably. It has a very characteristic appearance, and is easily distinguished, when seen in mass, from any other rock that I am acquainted with in New Zealand. It is well seen in Amuri, North Bluff, dipping 70° E., and at the Boat Harbour. It occurs again on the northern bank of the Conway, at its mouth, dipping 58° S.S.E.; from here it is not seen until the river Blyth is reached, from whence it continues along the coast to Stonyhurst, where it dips 30° S.S.E. It then runs inland, behind the Motanau flats (Sec. vii., *h*), and continues as far as Mount Cass. Further inland an isolated patch appears to rest on the south slope of the Black Hills, but I did not examine it. It is well seen in the upper or northern part of the Weka Pass (Sec. x., *h*), and can be traced continuously from there to the limestone gorge of the Waipara, where it rests conformably on the Ngarara group (Sec. ix., *h*), exactly as it does at Amuri Bluff (Sec. v., *h*). At all other places it is followed by tertiary rocks of different ages. It will be thus seen that although there is now no continuity of this rock between Amuri and the Waipara, the detached portions are at no very great distance from one another; and, as the composition of the limestone is one that usually belongs to widely-spread rocks we can have no hesitation in considering them as parts of one and the same bed, and we thus add the weight of the stratigraphical to the palæontological evidence that has been adduced in favour of the synchronism of the Waipara and Amuri Saurian beds.

This limestone generally forms the uppermost part of the mesozoic rocks, but at Flaxbourne it is covered by a yellow sandstone (Sec. viii., *h'*), and in the Greenbourne Creek, near Kaikoura, it appears to be also covered by argillaceous sandstones and shales, dipping 70° N.W., but I could not satisfy myself as to the age of these beds.

Fossils are not very abundant, but at Kaikoura Peninsula sharks' teeth are found in inter-bedded bands of conglomerate, and at Amuri *Brachiopods* and a species of *Siphonium*, apparently identical with one found in the Ngarara group at the same place, occur, as well as stems of three species of *Pentacrinites*, two of which cannot be distinguished from *P. rotatus* and *P. stellatus* of the Oamaru formation, but until the body and rays of these species are found it will of course be impossible to identify them. I have seen no fossils from the Amuri limestone, from either the Waipara or Weka Pass.

In the southern parts of the district this limestone forms no high mountains, but in Benmore, near Flaxbourne, it attains an altitude of 4,360 feet above the sea.

Contemporaneous Volcanic Rocks.—A very interesting group of volcanic rocks belonging to the Waipara formation is found at the Malvern Hills, and has already been described in detail by Dr. Haast (Geol. Reports, 1871–72, p. 1). The principal mass of the formation consists of liparite,* forming Mount Misery, the Rockwood Hills, and Snowy Peak Range. According to Dr. Haast these rocks overlie andesite,† but I had no opportunity of seeing this myself. On their southern, eastern, and northern flanks appear sheets of basaltic lava and tuffs, which, together with trachytic tuffs and agglomerates, are inter-stratified

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* These rocks are of very different texture to ordinary trachyte lava, and might properly be called "quartzose porphyritic trachytes," but the name is too cumbersome. I cannot adopt Dr. Haast's name of "quartziferous porphyry," as the quartz in that rock usually occurs in dodecahedral crystals, and not in rounded grains; and, from long association it conveys the idea of a trap-rock occurring in dykes only, and not of a volcanic rock associated with basalts, as is the case in the Malvern Hills. The following analyses of rocks from the Malvern Hills, made by the Chevalier Charles de Hauer of Vienna, are taken from Dr. Haast's "Report on the Geological Survey of the Province of Canterbury, 1864," p. 28.

—	A.	B.	C.
Silica	73·31	76·00	53·06
Alumina	11·00	7·16	19·76
Sesqui-oxide of iron	…	…	10·44
Protoxide ,,	1·55	5·00	…
Lime	5·32	…	7·90
Magnesia	…	3·76	6·00
Potash	4·70	5·30	…
Soda	2·40	2·22	0·50
Water	0·30	0·66	1·39
	98·58	100·10	99·05

A. White quartzose trachyte with garnets; Mount Misery.
B. Green quartzose trachyte; Snowy Peak.
C. Dolerite; Harper Hills.

† Dr. Haast calls these rocks melaphyre, but, as they contain olivine and are vesicular, I think that andesite is the more correct name.

with the coal formation. At the gorge of the Rakaia the liparites are so closely connected with the coal beds that they also must be considered of the same age, and on the western slope of Mount Misery a small seam of coal occurs dipping into the hill, and covered by liparite, Consequently I see no reason for supposing that the basalts of Harper Hills, etc., belong to a younger formation than do the liparites of Mount Misery and Snowy Peak, although the latter are undoubtedly older than the former.

The volcanic rocks from this district have already been described by Dr. Haast in the Report just alluded to, and by myself (Sixth Laboratory Report, 1871, p. 19), and several of them have been analysed by Mr. Skey (Seventh Laboratory Report, 1872, p. 15), so that all that is necessary for me to say here is, that the liparites often contain fragments of slate and sandstone, and although they cannot be considered as true fragmental rocks that have been ejected in an incoherent state, they have evidently proceeded out of the volcanic vent in a very different state from ordinary lava streams, and unlike any operation that we know of going on now on the surface of the earth, while the fact of coal being found a considerable distance up Mount Misery, and the way in which the trachytes are associated with coal beds in the gorge of the Rakaia, shows that they could not have been erupted in the deep sea. They belong to the massive accumulations of Richthofen.

On the western side of Governor Bay, in Banks Peninsula, liparites are found resembling those of the Malvern Hills, and as these rocks are not known to occur elsewhere in New Zealand, we must assume that this part of the peninsula is probably of upper cretaceous age. Whether the whole of the peninsula belongs to the same formation, or whether, as Dr. Haast thinks, the eastern part is much younger, I have no data for forming an opinion, but feel inclined to agree with Dr. Haast; nevertheless, I have in my map coloured the whole of the peninsula as belonging to the upper cretaceous period, for I think that such a course is the best for the present, until proofs are given that part of it belongs to a later formation.

At the Burnt Hills, north of the Waimakariri, streams of basalt occur similar to those of the Harper Hills; and in surrounding districts, such as the Kowai and Glentui, conglomerates formed of liparites are found. Consequently another centre of eruption has probably once existed between Burnt Hills, and View Hill, but it has now entirely disappeared.

Another interesting section occurs in the Acheron River, near Mr. Oakden's station (Sec. xi.), where the neck of an old doleritic volcano (*s*) is seen breaking through the upper palæozoic slates (*n*), and coal formation (*i*), and its tuffs (*s″*) and lavas overlaying, and perhaps interstratified with them. This appearance may, however, be deceptive, and the lava stream seen in the section (*s′*) on the north side of the neck may have been erupted through the coal formation. If this is the case, these volcanic rocks may belong to a later period than those of the Malvern Hills. This volcanic neck appears to have been instrumental in converting the coal into a kind of anthracite for some distance round.

Malvern Hills Coal Field.—Although by far the larger part of the coal of this district is inferior in quality to that from several other localities in New Zealand, its extent, its easily accessible position, and its proximity to Christchurch, make it one of the most important coal fields that we possess. The coal formation can be traced above the level of the Rakaia, from the Acheron all round the southern and western edge of the Malvern Hills as far as the Hawkins, a distance of forty miles, with but one break situated between the gorge of the Rakaia and the Point Station. In this district coal has been found at the Acheron, Rakaia Gorge, Rockwood, Selwyn River, and the Hawkins, so that there can be little doubt but that it extends continuously from one end to the other. The beds dip under the plains, but how far they extend it is impossible to say. The occurrence of outliers in the Burnt Hills, north of the Waimakariri, and at Glentui, north of the Ashley, shows that the formation once extended across the whole valley, and it is highly probable that a large portion of it still remains below the shingle plains; thus giving a great extent to the field. The coal seams have as yet been very imperfectly explored, and details of all that is known about them at present will be found in the Reports of Dr. Hector and Dr. Haast, already mentioned. The quality of the coal is variable, but undoubtedly by far the larger portion is brown or pitch coal. I do not think that the superior quality of the coal in Hart's and Hill's mines is in any way owing to the heat of volcanic rocks, and think that a far more probable explanation may be found in the seams having been formed by different kinds of vegetable matter, or possibly by their having been covered up by different kinds of rock, for the quality of coal in the same mine is known to vary with a difference in the roof. The anthracite of the Acheron, however, is a true altered coal, and appears to be due to the heat of the volcano which has burst through it, although I am aware that Mr. L. C. Miall has lately stated that there is "no evidence to show that a seam of anthracite has ever resulted from contact with heated rock" (Proc. Geol. Soc. of West Riding of Yorkshire, 1871–72, p. 24).

OAMARU FORMATION.

This formation usually contains an abundance of fossils, of which I consider the following to be the most characteristic, viz., *Pleurotoma hebes*, *Voluta elongata*, *Scalaria rotunda*, *Struthiolaria senex*, *Dentalium tenuis*, *Panopæa plicata*, *Protocardium serum*, *Inoceramus macilentus*, *Pecten williamsoni*, *P. fischeri*, *P. hochstetteri*, *P. hectori*, *P. hutchinsoni*, *P. athleta*, *P. zittelli*, *Ostrea incurva*, *Waldheimia gravida*, and *Terebratella gaulteri*.

The occurrence of *Panopæa plicata*, *Protocardium serum*, *Inoceramus macilentus*, as well as *Discoidea* (?) *australis*, *Caratomus nuperus*, and *Nucleolites papillosus* among the Echinoderms, gives a mesozoic appearance to the fauna, but all the rest are of decidedly tertiary aspect; and when we remember that eight species of the Mollusca, viz., *Voluta pacifica* var. *C*, *Calyptræa maculata*, *Gibbula nitida*, *Modiola albicostata*, *Pectunculus laticostatus*, *Lima bullata*, *Waldheimia lenticularis*, and *Rhynchonella nigricans* are still living in the adjacent seas, we can have no hesitation in assigning to the formation a date not earlier than the upper eocene period; and the occurrence of mesozoic forms only shows that the fauna of New Zealand had then, as it has now, a more ancient facies than the fauna of Europe.

Ototara Group.—This group is here represented entirely by calcareous sandstone, which, though coarse and rubbly at the Curiosity Shop on the Rakaia, is fine grained at the Waipara, whence it continues on through the Weka Pass round the northern slopes of the Doctor's Range, and along the ridge between the Omihi and Waikari Rivers in an easterly direction. Outliers also occur at the Hurunui township, and along the western slopes of the Black Hills, and also on the north branch of the Waipara, near Heathstock. In the Weka Pass and Waipara district it is much used for building, and goes by the name of Weka Pass stone.

But although the area of country occupied by this group is small, the well exposed junctions between it and the Amuri limestone in the Weka Pass, about two miles north of the hotel, and in the limestone gorge of the Waipara, make this district the most important in New

Zealand for studying the relations between these two formations (Secs. ix. and x.). In both the places mentioned the Weka Pass limestone is seen to rest on a water-worn surface of the Amuri limestone. At the base of the Weka Pass stone a thin bed of green calcareous sandstone, containing pebbles of the Amuri limestone, is often seen, and this green sandstone penetrates into the numerous fissures by which the Amuri limestone is almost always traversed, and fills them up; thus showing that the Amuri limestone must have been consolidated, jointed, and water-worn before the Weka Pass stone was deposited upon it. Both at the Waipara and at the Weka Pass, the dip of both formations is the same, but the Weka Pass stone overlaps the Amuri limestone, and wraps round it unconformably both along the northern slopes of the Doctor's Range, and the western slopes of the Black Hills towards the Hurunui Bridge. The Amuri limestone has also been denuded away to the west, towards Mount Donald, while the Weka Pass stone continues over its edge nearly as far as the junction of the Scargill with the Waikari River; while, as I have already mentioned, tertiary rocks of different ages rest on the Amuri limestone at different places.

It is therefore evident that a physical break exists between the Waipara and Oamaru formations, while the palæontological break between the two is almost complete; for out of twenty-two species of Mollusca belonging to the Waipara formation, and seventy-six species belonging to the Oamaru formation, one only (*Cucullæa alta*) is common to both.

Voluta elongata and *Scalaria rotunda* as well as sharks' teeth and imperfect Echinoderms have been obtained from the Weka Pass stone, and *Struthiolaria senex* occurs near Hurunui Bridge, but the Curiosity Shop is the only locality in this district in which fossils of the Ototara group are plentiful. From this locality have been obtained *Scalaria lyrata*, *Cucullæa alta*, *Pecten hochstetteri*, *Lima paleata*, *Waldheimia lenticularis*, *W. sinuata*, *Terebratella gaulteri*, *T. suessii*, *Rhynchonella nigricans*, *Pentacrinus stellatus*, *Hemipatagus formosus*, *Hemiaster posita*, and *Meoma crawfordi*.

Trelissic Group.—Rocks belonging to this group occur at Mr. Enys' station at Trelissic or Castle Hill, on the Broken River, a branch of the Waimakariri; and at the Waipara, forming Mount Brown; from whence they are continued through the Deans to the Weka creek, which they cross near the hotel, and form a large part of the eastern side of the Weka Pass. From here they continue on through Mount Donald towards the Waikari River. Another patch is found at Culverden, on the north side of the Hurunui Plains, and in the Black Birch Creek and Pahau River. The lower part of this group is composed of blue sandy clay, and soft yellow, grey, or green sandstone, generally with limestone or calcareous sandstone at the top.

The only places where the junction of this with the Ototara group can be seen, are in the Waipara district and the Weka Pass, in both of which places the upper group is seen to rest quite conformably on the lower. It has been stated (Geol. Reports, 1870–71, p. 14) that a considerable unconformity exists between the two in the Waipara, but this appearance of unconformity is caused by a fault (Sec. ix.) which crosses the Waipara in an east and west direction, the edges of the beds on the northern or downthrow side rising to the fault, as is so often the case in other places. Another apparent case of unconformity occurs in the upper part of the Weka Pass, but this is also owing to a fault. As the Weka pass is a most interesting district, and one that is easily accessible, I have given a section along its eastern side (Sec. x.), showing this fault, but as the section makes a considerable angle with the dip, it does not give a very good idea of the real position of these beds.

The fossils show that the two groups are closely related, as twenty-two per cent. are common to both.

The following fossils have been collected in the district, principally by Dr. Haast and J. D. Enys, Esq. :—

CULVERDEN.—*Lima paleata*, *Waldheimia lenticularis*, *W. patagonica*, *W. gravida*, *Rhynchonella nigricans*, and *Schizaster lyoni.*

BLACK BIRCH CREEK.—*Pecten hochstetteri*, *P. williamsoni?* *Waldheimia lenticularis*, and *Hemipatagus formosus.*

PAHAU RIVER.—*Gibbula nitida*, *Waldheimia patagonica*, and *Pentacrinus rotatus.*

BROKEN RIVER (L).—*Pleurotoma sulcata*, *Triton minimus*, *Voluta elongata*, *Marginella dubia*, *M. ventricosa*, *Natica ovata*, *Calyptrœa maculata*, *Crypta striata*, *Cylichna enysi*, *Panopœa plicata*, *P. worthingtoni*, *Mactra attenuata*, *Protocardium serum*, *Crassatella attenuata*, *Crenella elongata*, *Modiola albicosta*, *Pecten chathamiensis*, *P. hochstetteri*, *P. hectori*, *P. athleta*, *Lima bullata*, *Ostrea subdentata*, *Waldheimia lenticularis*, *W. concentrica*, *W. sinuata*, *W. patagonica*, *W. gravida*, *Terebratella suessii*, *Rhynchonella nigricans*, *R. squamosa*, *Echinus enysi*, *Meoma tuberculata.*

WEKA PASS (M).—*Natica solida, N. ovata, Scalaria lyrata, Struthiolaria senex, Cardium patulum, Venericardia intermedia, Pectunculus traversi, Pecten hochstetteri, P. diffluxa, P. hutchinsoni, P. polymorphoides, Waldheimia lenticularis, W. triangulare.*

THE DEANS.—*Waldheimia lenticularis*, a large species of *Selenaria*, often three inches in diameter, and *Caratomus nuperus.*

Contemporaneous Volcanic Rocks.—No volcanic rocks are associated with the Ototara group, but basaltic tuffs and lava streams, belonging to the Trelissic group, are found at Broken River, and also at Culverden and the Pahau. At the latter place very instructive sections are seen, the river Pahau passing through the neck of the old volcano. This neck is composed entirely of basaltic tuffs, while large beds of tuff containing marine fossils are interbedded with the surrounding rocks (Sec. xv., where *r* are basaltic tuffs, *f* altered shales, and *f'* limestone), while numerous dykes of basalt are seen cutting through the jurassic sandstones and shales for a considerable distance up the river. The tertiary rocks here dip 25° S.W. by W., while the dykes dip N.E. or N.N.E. at various angles, from 30° to 65°, and are therefore more or less at right angles to the strata, thus showing that the disturbance of the beds is posterior to the volcanic outbursts, and was not caused by them; this can also be inferred from the tuffs dipping with the sedimentary rocks, but the section that I have given shows that contemporaneous erosion and filling up was going on on a large scale.

AHURIRI FORMATION.

This formation is also found at Broken River, but is absent from the Waipara and Weka Pass district. It occurs also at Balmoral on the north side of the Hurunui Plains, and also in a small isolated hill by the Hurunui, called the Hurunui Mound.

The following are, I consider, the characteristic fossils of this formation, viz. :—*Buccinum carinatum, Voluta corrugata, Struthiolaria tuberculata, Cerithium nodulosum, Turbo superbus, Mesodesma grandis, Dosinia magna, Cardium spatiosum, Crassatella ampla, Pecten delicatula, P. semiplicata, P. triphooki, P. crawfordi,* and *Ostrea ingens.*

The lower portions are generally composed of shales and green sandstones passing upwards into shelly limestone. The junction between it and the Trelissic group is seen in the Cascade Creek, a branch of the Pahau, and at Broken River. In both places it rests on a water-worn surface of limestone belonging to the Trelissic group, and in the latter place it overlaps unconformably its edges. The fossils also show a considerable difference, only twelve per cent. being common to this and the Oamaru formations. The following fossils have been collected in the district, principally by Mr. J. D. Enys and Mr. Buchanan:—

BROKEN RIVER (U).—*Buccinum carinatum, Voluta pacifica, V. kirki ?, Mitra enysi, Natica solida, N. ovata, Struthiolaria tuberculata, Cerithium nodulosum, Turritella rosea, T. concava, Cladopoda monilifera, Calyptræa maculata, Crypta contorta, C. profunda, Turbo superbus, Dentalium conicum, Cytherea enysi, Dosinia subrosea, D. magna, Tapes curta, Cardium spatiosum, Crassatella ampla, Pectunculus laticostatus, P. globosus, Placunanomia, sp.*

HURUNUI MOUND.—*Natica solida, Turritella concava, Turbo superbus, Crassatella ampla, Pectunculus laticostatus, Venericardia intermedia.*

About 77 per cent. of the Mollusca are extinct.

PAREORA FORMATION.

This formation is largely developed in the district. It is found in the Wairaki Downs, near the Ashley; in the Mount Grey Downs, extending from thence in a north-east direction across the Waipara, by the lower part of the Weka Pass and Glenmark, down the valleys of the Waikari and Greta to the Hurunui. Another branch extends up the Waikari, round the northern base of the Doctor's Range to Horsely Downs, and the upper Waipara. It also occurs in the lower gorge of the Waipara, and extends along the coast as far as Stonyhurst, and into the upper valley of the Motanau. Further north it is found in the valley of the Blyth extending across the Hurunui, through the Cheviot Hills, across the Waiau-ua and up the valley of the Leader (incorrectly called the Eden in Stanford's map) to the Conway. From here it extends north to the Waiau township and Lyndon, and from thence in a north-west direction through Highfield, Mount Cookson, and the Whale-back, to the upper Conway. Small outliers are also found at the mouth of the Conway; at Amuri South Bluff (Sec. v.); Kaikourà Peninsula (Sec. vi.); and north of the mouth of the Clarence; while a considerable extent of country is covered by it from Cape Campbell to the Awatere, extending southwards across the Flaxbourne river on the east, and up the Awatere, beyond Blairich Creek on the west. Another outlier occurs, as I am informed by His Honour A. P. Seymour, on the Omaka Creek, near Blenheim. It is also largely developed near Nelson, where it extends from Blind Bay as far as Lake Rotoiti. Three other outliers also occur in the Mandamus, at Marble Point in the Waiau-ua, and in Herring Creek in the middle Clarence, which may perhaps belong to this formation. The last I have not seen, but it was described to me as consisting of limestone underlaid by green sandstone with coal, and the fossils in the two former are not sufficiently perfect for determination, and they may possibly belong to the Ahuriri or Oamaru formations.

The rocks consist of blue sandy clay, and soft gray or yellow sandstone, passing upwards in places into a coral or shelly limestone, while a calcareous sandstone occurs in the Jed, and beds of conglomerate at Gore Bay, Motanau, and Weka Pass.

Although palæontologically, this formation can be divided into upper and lower groups, which I have called respectively the Awatere and Kanieri groups, I quite failed in the field to detect any stratigraphical division. This may perhaps be owing to the similarity in the lithological characters of the rocks of both groups, or, as I am inclined to think, one may pass imperceptibly into the other.

Fossils are very unequally distributed, being in some places almost entirely absent, while in others they exist in great profusion. The following are, I consider, the most characteristic of the formation, viz. :—*Fusus nodosus* var. *D.*, *Buccinum robinsoni*, *Voluta corrugata* var. *B.*, *Struthiolaria cincta*, and var. *B.*, *S. cingulata*, and var. *B.*, *Cerithium rugatum*, *Turritella bicincta*, *Trochita dilatata*, *Crypta incurva*, *Dentalium mantelli*, *D. irregularis*, *D. lævis*, *Corbula dubia*, *Lutraria sulcata*, *Chione vellicata*, *Limopsis insolita*, and *Solenella australis*.

No junction between this and the Ahuriri formation occurs in the district, and the relations between the two will probably have to be determined in the Wellington Province.

In the Waipara and Weka Pass district, the Pareora formation rests on the Trelissic group, without any appearance of unconformity, although the whole of the Ahuriri formation is absent, but further to the east it wraps unconformably round the edges of the Oamaru formation. At Motanau (Sec. vii.); Amuri South Bluff (Sec. v.); Kaikoura Peninsula (Sec. vi.) ; Conway River (Sec. iv.) ; and Flaxbourne (Sec. viii.) ; it rests unconformably on the Amuri limestone.

The palæontological break between this and the Ahuriri formation is about the same as that between the latter and the Oamaru formations, thirteen per cent. of the fossils only being common to both.

The Pareora formation near Nelson differs so remarkably in its composition from the rocks found in other parts of the district that it merits a separate description. The lowest visible stratum is a conglomerate of syenite which forms the Arrow Rock at the entrance to Nelson Harbour;* it is overlaid by green sandstones containing large blocks of syenite which form the northern part of the Port Hills.

From this locality the following fossils have been obtained, viz.:—*Buccinum robinsoni*, *Voluta gracilicostata*, *Pectunculus laticostatus*, *Limopsis insolita*, and *Solenella australis*. These, I think, indicate that the Port Hills belong to the upper part of the formation, or Awatere group. In the same beds by the Wairoa, *Pectunculus globosus* and *P. cordatus* have been found. These rocks are distinctly interbedded with, and overlaid by, conglomerates with seams of lignite and brown coal, the latter also occuring among the sandstones. These conglomerates are composed of pebbles of slate and sandstone from the Wairoa and Maitai formations, and are so loosely cemented together that they often appear as ordinary shingle or gravel beds. These beds extend in a south-westerly direction up the valleys of the Waimea, Motueka, and Motupiko, as far as Lake Rotoiti, attaining an altitude of 2,334 feet above the sea, and forming the Moutere and Wai-iti Hills. In the whole of this district the upper portion is composed of true shingles. The lower sandstone beds probably underlie them through the greater part of the district, for they appear as green and dark grey sandstones mixed with conglomerates in a small creek about three miles from the entrance into Big Bush. These sandstones contain plant remains, and Mr. W. T. L. Travers informs me that several years ago he obtained a few marine shells out of them.

These are the beds referred to by Mr. Travers (Q.J.G.S., 1866, p. 254); they form flat-topped hills composed of gravels interstratified with sands, and the bedding is nearly horizontal. The pebbles in the gravels have been almost entirely derived from the Maitai formation which borders them on the south-east, few, if any, having come from the palæozoic mountains behind Rotoiti. Notwithstanding their recent appearance, I have but little hesitation in referring the whole of these gravels to the Pareora formation, partly from the way that they are interstratified with the sandstones at the Port Hills, and partly because they are evidently owing to causes that have long ceased to exist. Another proof of their age is the fact that they are older than the last great glacier period of New Zealand, which I have elsewhere shown (Trans. N.Z., Inst., V., p. 384), was probably of older pliocene date, or at any rate intercalated between the Pareora and Wanganui formations. The proof that these beds are of pre-glacier age is seen at Rotoiti, where the gravels attain a much greater height than the moraines, and the old glacier that once filled the bed of the lake (1,880 feet above the sea, *Haast*) is seen, after having ploughed out the gravels as far as it could, to have split into two branches, one of which proceeded east through the "old pass" towards the Top-house, while the main body went north-west into the valley of the Buller instead of taking its natural course into Blind Bay. These gravels therefore differ from those of the Canterbury Plains, which I shall presently show are younger than the glacier period.

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* Dr. Hochstetter is in error in saying that this rock "consists of altered schists streaked with veins of quartz."—("New Zealand," p. 470, foot note.)

Gold has been found in these gravels at various places, such as Biggs Gully in the Motueka district, and the gold-bearing gravels of Golden Gully in the Aorere district (Geol. Rep., 1870–71, p. 151), are probably of the same age.

Coal occurs in the formation in several places, such as up the Motanau River, where it has been described by Mr. Buchanan (Geol. Rep., 1866–67, p. 38), and near Nelson, from whence the following leaves have been described by Professor Unger :—*Phyllites nelsonianus*, *P. leguminosites*, *P. eucalyptoides*, *P. quercoides*, and *P. brosimoides*. A thin seam of pitchcoal also occurs at Highfield, in the valley of the Stanton ; it is only eighteen inches thick, and dips 85° E.S.E. It is underlaid by dark blue marl, which is separated from the jurassic rocks by a bed of conglomerate (Sec. xii.). Above the coal is a blue argillaceous sandstone. The marl contains fragments of a bi-pinnate fern, different from any that I have seen before, but it breaks up so much on drying that I could not preserve any specimens.

If also the outliers in the Mandamus and the middle Clarence belong to this formation, the coal found there will be of the same age. The seam at the former place has been described by Dr. Haast (Geol. Reports, 1870–71, p. 30).

Contemporaneous Volcanic Rocks.—Basaltic tuffs are interbedded with this series between Lyndon and the Hanmer Plains, and at Mount

Cookson; but I observed no particular points of interest about them. Some of the tuffs are cemented together by a white calcareous matrix, showing that, like the volcanic rocks of the Trelissic group, they also are of submarine origin. I believe that these rocks belong to the upper part of the formation, or the Awatere group. A basaltic dyke, with a beautiful columnar structure, occurs in Leslie Creek, on the Lyndon Station. It dips 70° S.E., and cuts through the lower beds of the Kanieri group. Mr. John Tinline informed me that a hill on the northern part of the Laurie Peaks, called the Wart, is also composed of basalt, but I had no opportunity of examining it myself.

The following fossils have been found in the district, principally collected by Dr. Haast and Mr. Buchanan:—

Awatere Group.

AWATERE.—*Fusus australis*, *F. dilatatus*, *F. nodosus* var. *D.*, *Purpura conoidea*, *Voluta pacifica*, and var. *B.*, *V. corrugata* var. *B.*, *Natica solida*, *Struthiolaria scutulata*, *S. cincta*, *S. canaliculata*, *S. cingulata*, and var. *B.*, *Turritella rosea*, *T. ambulacrum*, *T. tricincta*, *Trochita dilatata*, *Crypta contorta*, *C. incurva*, *C. striata*, *C. profunda*, *Pilæopsis radiatus*, *Trochus stoliczkai*, *T. circinatus*, *Gibbula nitida*, *Dentalium mantelli*, *Corbula dubia*, *Mactra inflata*, *Lutraria sulcata*, *Hiatula nitida*, *Venus zealandica*, *V. oblonga*, *Chione vellicata*, *Dosinia subrosea*, *D. grayi*, *Tapes intermedia*, *Pinna zealandica*, *Pectunculus laticostatus*, *Ostrea nelsoniana*.

MOTANAU (L.)—*Natica ovata*, *Struthiolaria scutulata*, *S. cincta*, *Crypta contorta*, *C. profunda*, *Dentalium lævis*, *Corbula dubia*, *Mactra inflata*, *Lutraria sulcata*, *Psammobia stangeri*, *P. lineolata*, *Venus zealandica*, *Chione vellicata*, *Dosinia subrosea*, *D. grayi*, *Tapes intermedia*, *Venericardia intermedia*, *Pectunculus laticostatus*, *P. globosus*, *Pecten secta*, *P. accrementa*, *Ostrea nelsoniana*.

MOUNT CAVERHILL.—*Natica zealandica*, *Turritella rosea*, *Turbo rubicundus*, *Dentalium mantelli*, *Venus vellicata*, *Venericardia australis*, *Modiola albicosta*, *Pectunculus laticostatus*, and *Pecten accrementa*.

MOUNT COOKSON.—*Turritella rosea*, *T. tricincta*, *Trochita dilatata*, *Corbula dubia*, and *Chione vellicata*.

Kanieri Group.

CONWAY RIVER.—*Natica solida, Solenella cumingi, S. australis.*

COURTENAY CREEK, Lyndon.—*Turritella rosea, T. pagoda, Trochita dilatata, Crypta incurva, Chione vellicata, Cucullæa alta, Pecten triphooki.*

RED SPUR, Lyndon.—*Natica ovata, Chione vellicata, Pectunculus laticostatus, Dosinia grayi.*

MAROA CREEK, base of Mount Cookson.—*Turritella tricincta* var. *B.*

WAIKARI.—*Fusus mandarinus, F. nodosus* var. *D., Ancillaria hebera, Voluta corrugata* var. *B., Struthiolaria cincta, S. tuberculata* var. *B., Cerithium rugatum, Turritella tricincta, Rotella zealandica, Dentalium giganteum, D. solidum, Chione vellicata, Modiola albicosta, Cucullæa ponderosa* var. *B., Limopsis insolita, Astropecten sandersoni.*

LOWER GORGE OF THE WAIPARA.—*Voluta pacifica, Natica solida, Struthiolaria cincta, S. tuberculata* var. *B., Trochita dilatata, Crypta costata, C. incurva, Mactra inflata, Lutraria solida, Cytherea enysi, Dosinia subrosea, D. grayi, Venericardia intermedia, Modiola albicosta, Pectunculus laticostatus,* and *Lima crassa.*

WEKA CREEK.—*Turritella tricincta, Turbo granosus, Rotella zealandica, Mactra discors, Chione vellicata, Venericardia australis,* and *Ostrea purpurea?*

About 66 per cent. of the Mollusca of this formation are extinct, so that it can be referred with tolerable confidence to the upper miocene period.

GLACIER DEPOSITS.

Besides the moraines of Lake Rotoiti, which I have already mentioned, glacier deposits are very clearly seen in the valley of the Upper Waiau-ua, both about Lake Guyon, and below the Henry River; the former locality will, I believe, be described by Mr. W. T. L. Travers in a paper to the New Zealand Institute. At the Henry River, the valley of Waiau-ua is crossed by a large terminal moraine, which gave origin to a lake that once extended all over the Ada Flat and joined Lake Guyon, but has long ago been entirely filled up.

The waters of Lake Tennyson, near the head of the Clarence, are held back by a moraine; but there is no evidence to show whether a rock basin exists there or not. A glacier also came down the Rainbow

Valley, and flowing over the spur dividing that river from the Wairau blocked up the valley, forming a small lake up the Wairau Gorge. The moraine of this glacier can still be traced, but the greater part has been washed away by the river.

The only other locality in which I saw evidence of glacier action is the valley of the Rakaia, which has been fully described by Dr. Haast. The terminal moraine of this immense glacier, which must have been some forty-five miles long, was situated below the Rakaia Gorge, from the slopes of Mount Hutt to the Point Station, near Rockwood, extending west, nearly to the Wool-shed Hill, which is composed of gravel, and has nothing to do with the moraine. The position of this moraine is still marked by large angular blocks of stone from the palæozoic mountains, but the actual moraine itself has been completely washed away, leaving the largest blocks mixed up with, and resting upon, the rounded pebbles of the plains. These blocks are generally found in small hillocks raised above the surface of the plains; but this is owing to the greater resistance that the blocks have offered to the denuding agencies which have lowered the rest of the plain, and they cannot by any means be taken to be portions of the original moraine itself, for, with the exception of the few large blocks, these hillocks are entirely composed of rounded pebbles exactly similar to those of the surrounding plains.

Besides the moraines and *roches moutonnées*, I noticed a *bloc perche* on the north side of the road near the Acheron, seated on the top of a *roche moutonnée*, but I could find no striæ either in the Upper Waiau-ua, or even in the hard sandstones of Lake Coleridge.

Lake Guyon, Lake Coleridge, and probably also the old lake in the Upper Waiau-ua, are true rock basins. Lake Lyndon is not a glacier lake at all, but owes its origin to the large amount of detritus that has been brought down by a small stream from the Big Ben Range, and which has filled the valley across.

Post-Glacier Deposits.

Under this head I propose to include all the shingle plains that occur in the district, although they are, no doubt, of different ages; and, as the most interesting point concerning them is the evidence they show as to their origin, I shall not take them in a chronological order, but arrange them in the way that appears to me to be best adapted for leading up to the inference that all of them, except perhaps the Hanmer plains, have had a common origin.

Hanmer Plains.—These plains are about 1,200 feet above the sea [Dr. Hector makes them 1,360 feet (Trans. N.Z. Inst., III., p. 297), and Dr. Haast 1,162 feet (l.c., p. 294)], and are about twelve miles in length and four in breadth. They lie in an east and west direction, and are entirely surrounded by mountains. Three rivers run into them, viz., the Waiau-ua from the west, the Percival from the north, and the Hanmer from the east, and all three converge to the same point (about the centre of the southern boundary), and escape to the south by a narrow gorge. The lower portion of the plains is composed of blue clay with lignite, under- and over-laid by gravels, which are roughly stratified with beds of sand (Sec. xvi.), and are covered with silt, on an eroded surface of gravel, in the northern parts. These gravel beds attain along the south margin an elevation considerably above the plain, and form a thick capping on each side of the gorge by which the rivers escape, the gravels being beautifully terraced by the Waiau-ua and the Hanmer. There is, I think, little doubt but that the lower parts of these plains were formed in a lake, which has been drained by the cutting of the Waiau-ua Gorge; but the origin of the lake, which must have lain in a rock basin, is uncertain. The configuration of the surrounding mountains, and the absence of any signs of glacier action in the district, discountenance the idea of its having been a glacier lake, while its proximity to the volcanic district north of Lyndon, and the occurrence of hot springs in the plains themselves lend support to the probability of its having been due to local subsidence, which, in other localities, can be shown to have often followed the extinction of volcanic action (see Description of Nga-tutura, Q.J.G.S., 1869, p. 13).

Motanau Upper Beds.—At Motanau the sea cliffs are about eighty feet high, and the upper twenty-five feet of them is composed of sands and grits (Sec. vii., *a*), from which the following shells have been obtained, viz.:—*Fusus corticatus*, *Calyptræa maculata*, *Crypta contorta*, *Imperator imperialis*, *Rotella zealandica*, *Polydonta tiarata*, *Gibbula nitida*, *Siphonaria denticulata*, *Ampullacera avellana*, *Dentalium pacificum*, *Mulinia notata*, *Tellina deltoidalis*, *Mactra rudis*, *Mesodesma cuneata*, *Mytilus magellanicus*, *Modiola albicosta*, *Pecten zealandia*, *Terebratella rubicunda*, and *Rhynchonella nigricans*.

All these are recent species except *Mactra rudis*, which is also found, in the alluvium of the Thames, on a raised beach at Opotiki, in the alluvium at the head of Dunedin Harbour, in a raised beach at Cape

Kidnappers, and at the upper pleistocene beds at Wanganui, but in none of an older date. From the top of these cliffs the land forms a terrace sloping gently upwards for about two miles, where it attains a height of at least 150 feet above the sea, and the sands with recent shells, together with shingle, cover the whole of it. This terrace extends as far as Stonyhurst. At the north head of the River Blyth, stratified shingle, resting unconformably on the Pareora formation, forms hills 500 feet high, and at Gore Bay silt also occurs unconformably on the top of the Pareora formation.

South of the Conway a similar terrace is seen, formed principally of gravels, but it is here followed by two other terraces (Sec. xiii., *a*) cut out of the rock, the upper of which is at least 300 feet high. North of the Conway, as far as Amuri Bluff, and the whole of the Kaikoura Peninsula, is also another level-topped terrace about 200 feet above the sea, but worn now into downs by the streams. The Amuri terrace is capped by gravels, but neither in this, nor in the terraces south of the Conway, did I find any shells. The whole of the shingle seems to have been removed from the top of the Kaikoura Peninsula.

All these terraces are certainly due to marine action, and there can be no doubt that in geologically recent times the sea stood here at least 300 feet higher than it does now. The Charwell plains, which slope gently up to the upper Conway, attain a height of 1,500 feet, and are also evidently due to marine denudation.

Hurunui Plains.—The Hurunui plains are from 600 to 800 feet above the sea level, and slope gently seawards rather faster than the beds of the rivers that intersect them. They lie in a south-west and north-east direction, or nearly parallel to the coast line, and are about thirty-two miles in length, from the Waipara to the Waiau-ua, with an average breadth of eight or nine miles. They are composed almost entirely of shingle and silt, and resemble in appearance the Canterbury plains. They are entirely surrounded by hills, but have three narrow openings to the sea through which the Waiau-ua, the Hurunui, and the Waipara run. All these rivers run through rocky gorges, but the gorges differ from that by which the Waiau-ua leaves the Hanmer plain in not having a shingle capping on them ; indeed the shingle does not reach to within a considerable distance of the tops of the gorges. This shows that the rivers have not cut their gorges entirely themselves, for if they had done so they would have first built up their shingle beds to the levels of the tops of the gorges, or else formed a lake. But that the

Hurunui plains are not due to a lake is certain, not only from their seaward slope, but from the fact of their having three openings, for no lake can have more than one outlet.*

One other explanation is alone left, which is, that these plains owe their origin to the sea, which entering the valleys swept out the soft tertiary rocks that then extended over the plains, and wore down the gorges, but not, perhaps, to the same level that they have now.

Canterbury Plains.—The northern part only of the Canterbury Plains comes into the district under review. This portion is about forty-five miles in length—from the Rakaia to the Forty-Mile Beach, and about the same in breadth—from the Oxford Downs to Lake Ellesmere. It rises gradually from the sea with a gentle slope that is rather greater than the beds of the rivers until it attains a height of 800 feet, at the foot of the Malvern Hills, where it wraps round the spurs at the same level that it has in the valleys, precisely like the Southland plains. Continuing its slope up the valley of the Rakaia, the highest point is reached about Fighting Hill, where it attains an altitude of 1,700 feet above the sea. From this point it slopes down again to an altitude of about 1,300 feet at the Acheron, where the shingle thins out (Sec. xiv.). This highest point of the slope occurs just at the narrowest part of the valley, between the slopes of Mount Hutt and Fighting Hill, and it exactly resembles the bar across the entrance of a sound or harbour.

The pebbles which compose this shingle bar might just as well have come from Mount Hutt, and been drifted across by the wash of the sea, as have come down from the sources of the Rakaia, and it is impossible to imagine a river building up such a bar. It must not be supposed that this bar is an ancient moraine, for it is composed entirely of water-worn shingle like the rest of the plains, and as it extends high above the rocks forming the so-called "gorge," it cannot possibly be the shore of an old lake dammed back by the rocks of the gorge; indeed, the sea is the only agent that could have formed it. If a lake ever existed here it must have been a brackish-water lagoon like Lake Ellesmere, and not a glacier-lake like Lake Coleridge. The same remarks apply to the Waimakariri. The so-called "gorge" of this river is simply a cutting

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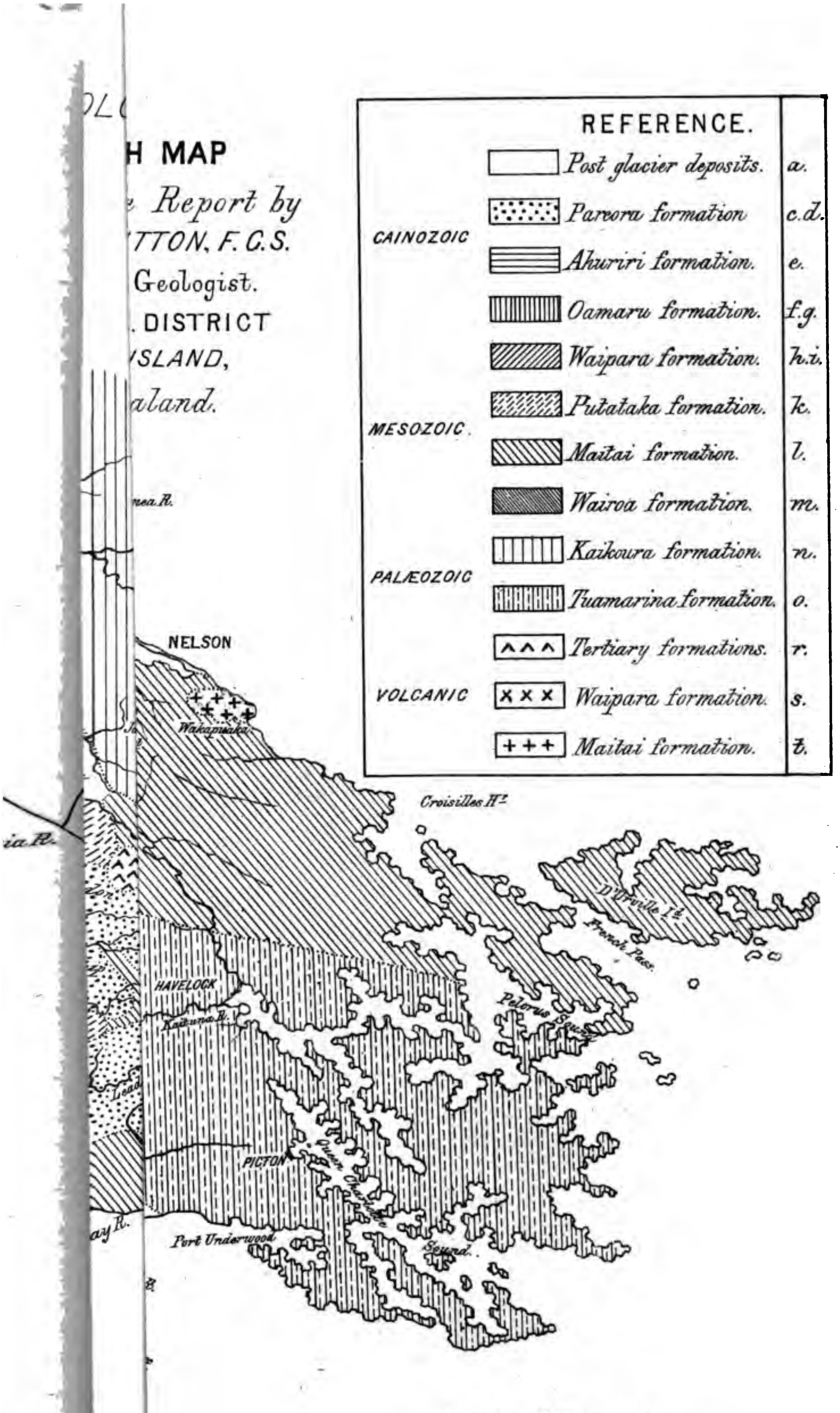
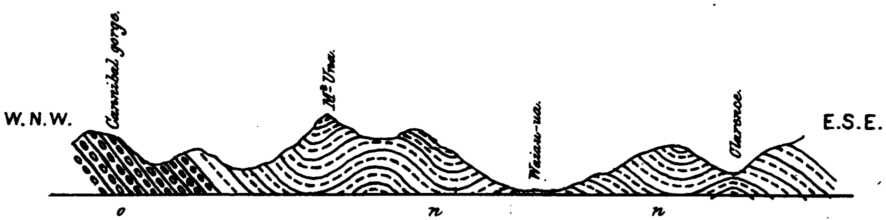
* The reason for this is obvious. If we suppose for a moment that a lake had two outlets, it is evident that both would not wear down exactly at the same rate; but as soon as one got lower than the other all the water would escape by it, and wear it down still more rapidly, while the other old outlet would be left above the level of the lake.

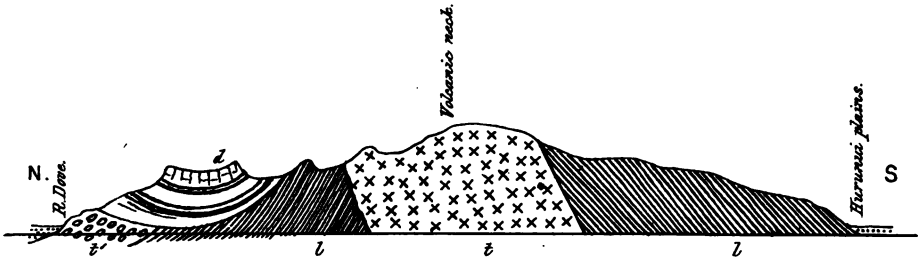


SCALE. 12 Miles = 1 Inch.

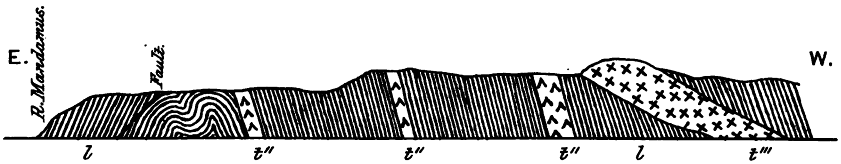
J. Buchanan del. et lith.



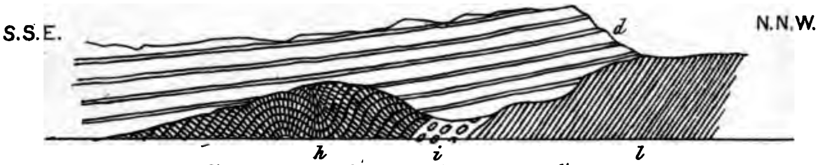
Section I. SPENSER MOUNTAINS, 25 Miles.



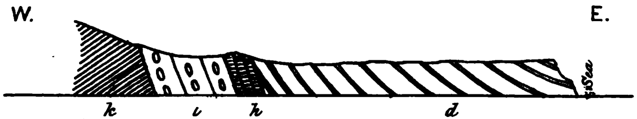
Section II. MANDAMUS, 2 Miles.



Section III. MANDAMUS, 1/2 Mile.

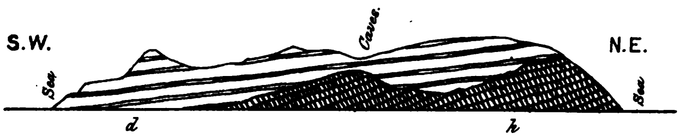


Section IV. CONWAY RIVER, 1/4 Mile.

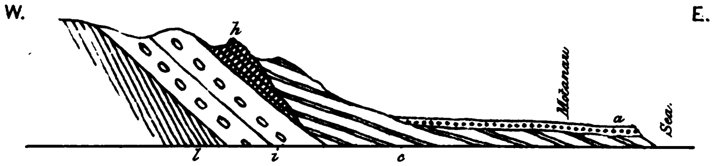


Section V. AMURI, SOUTH BLUFF, 1 Mile.

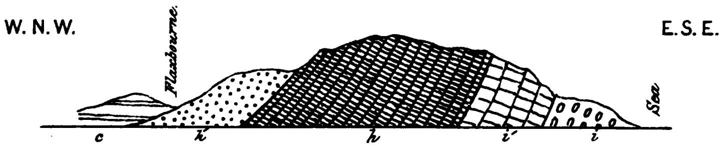
Capt Hutton del: J.B. lith.



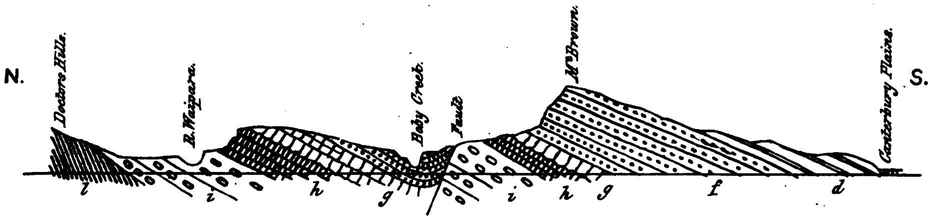
Section VI. *EAST HEAD, KAIKOURA PENINSULA, 1 Mile.*



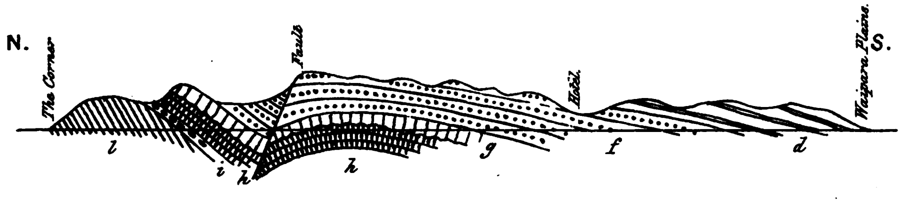
Section VII. *MOTANAU, 3 Miles.*



Section VIII. *FLAXBOURNE, 12 Miles.*

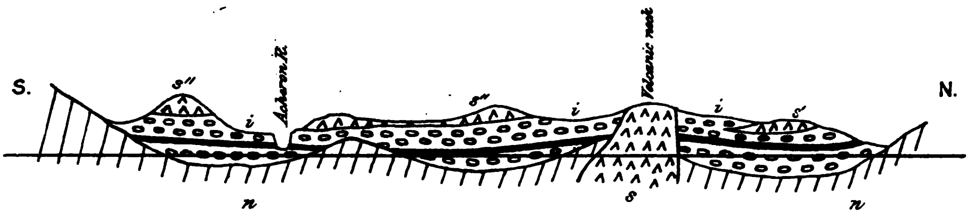


Section IX. *WAIPARA, 6 Miles.*

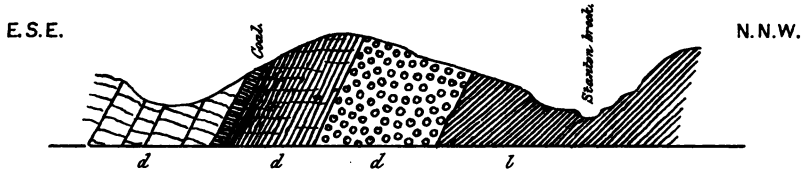


Section X. *WEKA PASS, 4 Miles.*

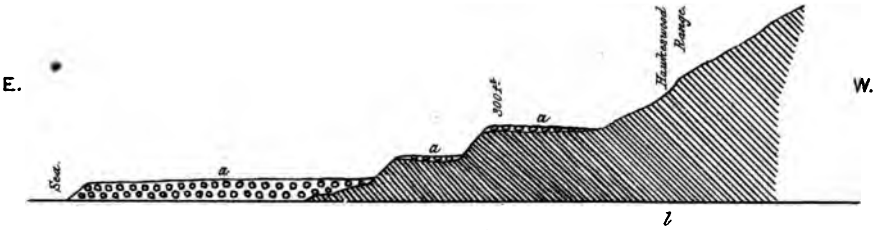
Capt. Hutton del. J.B. lith.



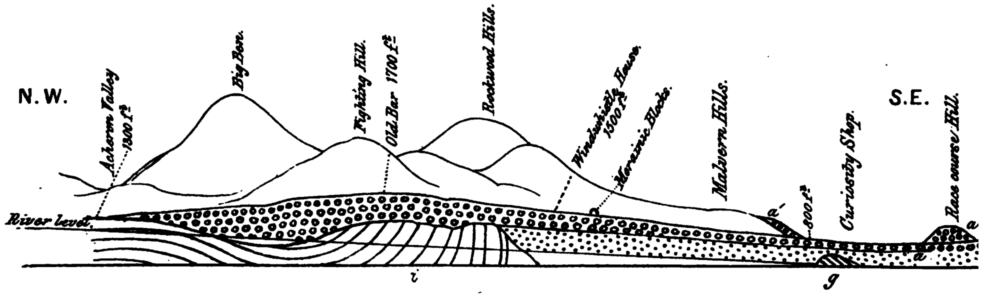
Section XI. ACHERON, 3/4 Mile.



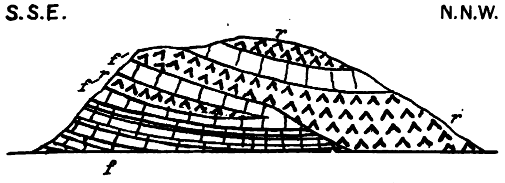
Section XII. HIGHFIELD, 150 Yds.



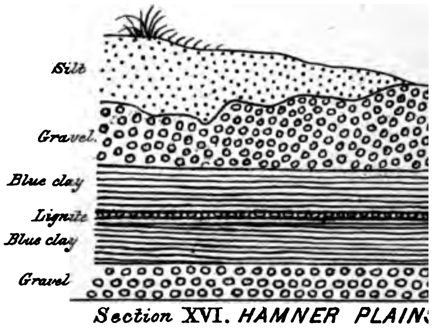
Section XIII. SOUTH HEAD OF THE CONWAY, 1½ Miles.



Section XIV. RAKAIA GORGE, 14 Miles.



Section XV. PAHAU, 100 Yds.



Section XVI. HAMNER PLAIN

Capt. Hutton del. J.B. lith.

through a low isolated hill which is entirely surrounded, and almost covered, by shingle; this hill could never have dammed back a lake. No bar crosses the valley of the Waimakariri, partly on account of its far greater breadth, but principally because the Malvern Hills would not supply the hard rocks necessary for the pebbles, and by sheltering the bay from the south-east winds would prevent the shingle being drifted across.

That the shingle of the plains once attained a higher level than it has at present is proved by the existence of the Race-course Hill (Sec. xiv.), Little Race-course Hill, and Wool-shed Hill, all of which are composed of shingle, and by the occurrence of shingle all round the base of the Malvern Hills, some fifty to seventy feet higher than the present level of the plains, (Sec. xiv. *a*′). Nothing but the sea could have so lowered the plains, and still left them level.

The eastern portion of the Malvern Hills also exhibits a plateau or terrace, now much cut up by the streams, which rises gently from about 1,100 to 1,200 feet above the sea; and this is evidently a sea-worn surface. This plateau affords in itself no evidence of its being a pleistocene sea surface, but taken with the other facts adduced, it increases the probability of the marine origin of the plains, for the summit of Race-course Hill also reaches the same slope as that of the Malvern Hill plateau, so that probably the same cause that formed the plateau piled up the shingle of Race-course Hill.

The nature of the deposits forming the Canterbury plains is well seen in the bed of the Rakaia, from the gorge to " Shingly Chasm." The lower part consists of sand and clay with small shingle, while the upper is large shingle. The line separating these deposits is clearly marked, and the top of the lower portion is exactly on a level with the top of the rocks at the lower end of the gorge, and slopes gently down to the west. Very much the same thing can be seen below the Waimakariri Gorge. The lower portion has, as I suppose, been deposited during subsidence, and is probably of newer pliocene age, while the upper portion has been deposited during elevation, and is of pleistocene age. The lower portion would probably have been all washed away during the elevation if it had not been protected by the rocks forming the gorges.

It is remarkable that the left bank of both the Rakaia and the Waimakariri is covered with shingle, while the right banks of both are good agricultural land. It would be difficult to account for this phenomenon by the theory that the plains have been formed sub-aerially by the rivers, but an explanation is readily found if we assume that they were formed by the sea assorting the materials poured into it by the rivers during a slow elevation of the land, for then the same south-easterly winds which drove the shingle from Mount Hutt over to the Malvern Hills, would still, as the land rose, drive the shingle as it came from the rivers to the north of the river mouth, which would ultimately form the left bank of the river.

I have shown, then, that we have certain evidence in the marine terraces between Motanau and the Conway that the sea in quite recent times stood at least 300 feet higher than it does now, and there is quite independent evidence, both in the Hurunui and Canterbury plains, that each owe their origin to the sea; and when we remember that at equal distances from the sea the Hurunui and Canterbury plains are at the same level, the conclusion is irresistible that nothing but the sea could have formed them; and the fact of the terminal moraine of the old Rakaia glacier having been washed away, as already mentioned, shows that even the oldest part of the plains is of post-glacier date.

I have, therefore, no hesitation in stating my conviction that the central portion of the Canterbury plains has risen 1,700 feet since the commencement of the pleistocene period.

REPORTS RELATIVE TO COLLECTIONS OF FOSSILS IN S.E. DISTRICT OF THE PROVINCE OF OTAGO.

BY ALEXANDER McKAY.

To the Director of the Geological Survey.

15th December, 1873.

Sir,

In compliance with your instructions, received on the 4th Sept., 1873, I sailed for Dunedin by the first opportunity, arriving there on the 7th September.

Next day being wet and stormy I did not leave for Saddle Hill until the afternoon coach.

On the following day I examined the railway cuttings in the vicinity of the Chain Hills for fossils, but failed to find any. I then went up to Abbott's Creek, returning by way of Green Island, but was still unsuccessful.

At the new shaft being sunk for coal on Mrs. Shand's property I found a large quantity of greensand concretions, which had been obtained in sinking the shaft. They occurred at various depths, but I could not learn whether or not their contents varied at the different levels, as they had been thrown aside promiscuously.

These masses contained a very considerable quantity of fossil shells and leaves, sometimes mixed, and sometimes of only one class in the same mass. I collected here on the two following days (the 10th and 11th of September); the 12th was very stormy, and I was unable to do anything outside. Next day (the 13th) I found a bed of fossilised roots, apparently sticking in an old soil just as they grew.

This bed crops out at the old toll-bar, on the road from Green Island to Boat Harbour, and apparently at no great distance above the coal bed which was being worked, as shown in Section No. 2. On the 14th I went in search of Belemnitella beds at Boat Harbour, and succeeded in finding them without much difficulty. I found the Belemnitella was associated with another shell of what appeared to have been of considerable dimensions, of a black colour, but so broken as to defy reference to any particular kind of Mollusc. I found that the calcareous portion of the bed extended horizontally to a very limited extent, soon passing, in all directions in which examinations could be made, except seawards, into a coarse quartzose sand or gravel bed, though at some points, perhaps, the calcareous matter amounted to 90 per cent. Below this bed were loose quartz and sands, both coarse and fine, and having streaks of coal in them. A workable coal seam underlies these in a gully to the west, and this is itself over quartzose drift, which lies on the mica slate, and this, running in a ridge from Boat Harbour Point nearly west, forms the boundary of the coal field. These Belemnitella beds are overlaid by greyish (impure) greensands, which pass into pure greensands, often very hard, overlaid by a very black shale of a crumbling character.

This rock is overflowed by the volcanic rock crowning Saddle Hill. I did not examine Saddle Hill to the south-west, but have no doubt that all the same rocks are to be found, as the greensands and quartz sands are to be seen on the north-west side of Saddle Hill. I failed to find any other fossils here, and, after collecting one day from material excavated from the Caversham Tunnel, I made ready to go to Tokomairiro, where I arrived on the 15th September.

I found that the part of the quarry which was being opened when Mr. Buchanan was there had never been further opened, the blocks whence the Cetacean bones were obtained not being *in situ*. No regular quarry has since been opened, as the dip of the bed requires considerable stripping to get at the stone.

I collected from a bed underlying the limestone considerable numbers of fossil shells and one Cetacean bone. This being all that I could at present do, I left for Tokomairiro on the 17th of September. Arrived there, I found that the wet weather had stopped all communication with Coal Point, by way of which it had been my intention to reach Nugget Point. I therefore took coach for the Clutha Ferry, and from there the steamer to Port Molyneux.

Here I learned that the existence of the fossil Saurian at Bloody Jack's Island was well known to everyone, and so I determined to go there at once, for fear curiosity-hunters should injure it before I had the opportunity of seeing it. Accordingly, next morning, the 19th Sept., I left Port Molyneux for Catlin's River, by way of Glen Oamaru, having procured assistance to carry my swag, arriving at Rae's accommodation house in the afternoon. Next day I went to the Old

Mill, Owake Creek, to procure a boat, but none being that day available I had to content myself collecting in a cutting of the road, from the school-house to a point on the creek bank, a quarter of a mile above the Old Mill.

Next day (Saturday) was wet, and Sunday too, so nothing was done until the following day, when I procured a boat, with a boy to guide me, and went to the beach opposite Bloody Jack's Island. I doubt whether the boy spoke the truth when he pointed to a few fragments of a fossilised tree as the specimen of Professor Black, and I examined carefully all the flat tabular rocks as far as it was possible to go, and nowhere could I see anything like bone. I procured a few shells from a sandstone band that overlies the black shale with fossil wood, and, disappointed, returned to the Pilot Station. It so happened that the pilot had also been with Professor Black's party, and had assisted to get out some small portions of the supposed skeleton. He promised to go with me next day, and point it out. This he did, pointing out to me the same pieces of wood as the boy had done. This fairly convinced me that the whole thing was a mistake.

Under the cliffs at the north end of the sandy beach on the mainland, opposite Bloody Jack's Island, are limestone nodules in the black shale full of a great variety of shells in a beautiful state of preservation. Some of these shells, though very scarce at the Amuri Bluff, are found here in great abundance, and the reverse is the case of some few shells which are very scarce here. Being without heavy tools I deferred attacking these masses till a future occasion, and meanwhile returned to the Old Mill.

Next day I went to the Sandspit, north of the mouth of the Catlin's, and camped there while I made collections of moa bones, etc., found in the sandhills, and fossils at the further end of Cannibal Bay.

Unfortunately the weather again broke, and after camping out for three days, which I employed chiefly in collecting among the sandhills, I returned to the Old Mill.

On the 29th of September I went to collect fossil ferns in the Owaki, near the bridge, but I did not succeed, although I persevered all day in the rain. It was not until the evening of the second day's search that I hit upon the proper spot, which I could not previously get at, owing to its having been under high-water mark. Next day I made a considerable collection, and, having taken them to the Old Mill, spent the 2nd and 3rd of October in packing them.

On the following morning I left the Old Mill to make collections at the south of the Catlin's mouth from the masses before alluded to, and I was so employed till the 8th October in getting them carried to the Mill and packed.

The 9th of October I employed in digging out whale bones from a creek in the bush at the north end of Cannibal Bay, to which spot they had apparently been floated during a very high tide.

Getting these bones to a spot where I might bring up a boat for them, and the bringing the boat from the beach of Bloody Jack's Island, employed me till the 13th of October, on which day I started for Nugget Point to collect there, leaving the despatch of my collection at Old Mill until my return to that place. Not being able to find the common path, I struck at hap-hazard into the bush, having nothing to fear with the sea on my right hand. On crossing the second ridge from Cannibal Bay I came on to the coast at a small cove with a rough, shingly beach. Here fossils were abundant, and, after making as good a collection as time would permit, I proceeded on my journey. At the north side of the next bay, deeming the coast line impracticable, I struck into the bush, finding, however, that it was so hard to make progress that I was unable to reach Molyneux Bay that night. I however reached the Nuggets early next morning, and immediately commenced work in the cutting that leads up to the lighthouse. Here I got fossils, the importance of which did not appear until I had examined the same beds in other localities.

Next day I collected in Roaring Bay, but was disappointed in not finding the Ammonite bed. I found numbers of fossil shells, all of them, however, in masses on the beach.

The 15th was so stormy, with the sea running so high, that, being unable to pass the bluffs at low water, I could not see where the parent rock was. The following day I followed the shore further, discovering the bed rock of such shells as I had already collected, and I eventually hit upon the Ammonite bed. Knowing well that these shells might not be found elsewhere in an equal state of preservation, I decided to make my principal collection here. I have not obtained elsewhere the same number of species, neither are they to be found so beautifully preserved in any other place. I collected here until the 27th October, and during that period I followed these beds till, becoming unfossiliferous and continuing to preserve the same strike and dip, they reached that point where the fossils reappeared in the second bay from Cannibal Beach going north. No unconformity appears, as far as I could see, though there are several beds of coarse sandstone and conglomerate just below the last appearance of Pholdomya, which might be the passage beds between the two formations.

At the north end of Cannibal Bay is a shell which I have described to you as an Ammonite. This, or a shell very like it, is to be found in the highest bed of the Nugget Point or *Productus* formation; but this can only be decided after examination of the specimens collected.

On the 27th October I finished, and hearing that a seal had been killed the same day on Cannibal Bay beach, I left for that place to secure the skin on the 28th. At the same time I got the skeleton of a seal and the remains of a whale.

I spent three days, from the 1st to the 3rd November, in a fruitless attempt to get to Tautuku, and failed, from the impervious nature of the bush. The time, however, was not entirely wasted, as I obtained a view of the south-west side of Bloody Jack's Island and the coast to the south-west generally, which I was very anxious to see. The results of this are shown in a section.

Returning to the Old Mill on the 4th November, I packed and shipped the collection there, and left on the next day for the vicinity of the Hon. Mr. Richardson's. Here I found the same bed as is in the cutting that approaches the Nugget Point Lighthouse. I also found an oyster bed and many shells in the intermediate part of the formation, which same is almost barren in the beds at Roaring Bay. The upper *Productus* and the Ammonite bed do not seem to be represented here, though they occur some distance further west.

The ridge which forms Nugget Point Promontory is mainly composed of hard, unyielding strata, and can be traced thence to the Popotunua Gorge, the crumbling shales of the beds in Roaring Bay forming a deep valley on its south side, which is remarkably continuous, in spite of the large creeks cutting across it, as, for instance, the Oamaru, Puerua, Kahiku, and Waiwera, all of which have part of their course in this valley.

The oyster bed of Roaring Bay is to be found all along this valley, and on either side here and there are other shell beds, as shown in the plan.

On the 7th and 8th I followed this valley, and found, at the point where the Puerua turns south to leave the valley, that the strike and dip are very different to the general direction, and, but that the fossils are the same, I should have concluded that there was unconformity at this point.

Proceeding along the oyster bed as far as the low saddle dividing the Puerua from Kahiku, I turned down the stream, and, near Mr. Campbell's station, met with fossil ferns underlying the lowest shell bed yet found. I discovered two sorts, one of which was very like those found at the Owake Creek. Before making a collection here I pushed on to the furthest locality marked in the plan accompanying my instructions, but, not finding fossils there in any quantity, I returned to the Kahiku, bringing a few with me, and collected there for two days. I was also further detained two days by the weather. After this I returned by way of the Hon. Mr. Richardson's, and finished on the 20th November. I took the collection to Port Molyneux, and came by coach to Dunedin, whence I sailed for Wellington, arriving on the 26th, having been absent 82 days.

With respect to the geology of the district described in my instructions as "Nugget Point, Catlin's River, and Kahiku Ranges," at first sight it seems simple enough, being nothing more than a great succession of conglomerates, coarse and fine-grained sandstones alternating with dark-coloured, indurated shales with calcareous concretionary nodules. The beds strike N.W. by W., and dip at an angle varying from almost vertical to 30°.

In the northern division of the district there are two strongly-marked beds of conglomerate, one skirting the north flank of the Kahiku Range, and crossing the Southland Road as you enter Popatuna Gorge, and last seen by me at the junction of the two roads from Port Molyneux and Balclutha to Catlin's River. This is composed chiefly of crystalline rocks, with masses of a considerable size. Below this lie shales, dark in colour, crumbling in character, and, where observed near Whylock's Hotel, very much disturbed. Above this, in the Kahiku Gorge and Popatuna Gorge, are sandstones with plant remains, and, in the Kahiku Gorge, fossil ferns not very different from those in the Owake Creek, but characterized by the nature of the associated shells.

The next conglomerate bed is one of great constancy also, being traceable from the beach in Roaring Bay, appearing in the Gorge of Oamaru, and all along the south side of the Kahiku Range.

Between these two conglomerate beds lies the lower shell bed, in which I have never observed any chambered shell, nor either of the two forms which, in writing to you, I have described as Oyster and Turritella; while, on the other hand, this part of the formation contains shells not found in the upper part of the *Productus* bed.

Immediately above conglomerate No. 2, chambered shells are to be found, only sparingly however, as these shells do not reach their full development nearer than a point considerably higher up in the formation.

The fossils of this bed are—scarce at Roaring Bay, although common in the Puerua—not to be found, so far as I could see, in the Kahiku and Popatuna Gorges, but they might perhaps be found if carefully searched for.

This bed is overlaid by the so-called oyster bed, which is a conglomerated mass of fossil shells nearly a chain in thickness, and almost wholly composed of shells. In this oyster bed I first found the shell I have described as Turritella. Although found in great quantities in the upper part of the bed, it is not to be found in the lower; but as this oyster bed is underlaid by coarse sandstones of considerable thickness, which contain plants. These shells do not occur again till the Ammonite bed is reached, and here, in a thin bed of conglomerate associated with Saurian bones, it is plentiful, showing that its absence from the underlying sandstone was not due to the simple fact of its having been a sandstone, but more probably because it was deposited in brackish water, as the abundant plant remains would testify, while we have seen shelled molluscs could be fossilized on a pebbly beach almost verging on a conglomerate.

This streak of conglomerate, about a foot in thickness, divides the Ammonite bed into two parts, and it is the matrix of the few Saurian bones I found at Roaring Bay.

The Ammonite bed above it is very rich in chambered shells of various genera, and it rests on soft shaly sandstones and shale with calcareous masses; and here the Ammonites, etc., have disappeared, and are replaced by a variety of new shells overlying the chief bed of the *Productus*, forming the furthest projecting point of the bluff and the S.W. head of Roaring Bay. Beyond this the beds are fossiliferous for perhaps half a mile further than Roaring Bay on the coast line.

Standing on the top of the range south of the source of the Kahiku, it is easily seen that all the beds to the south-west dip in the same direction as the underlying beds, and hence we should conclude that the whole must have been deposited before any very great elevatory movement took place. From the same point of view it becomes forcibly impressed on the mind of the observer that the configuration of the country, as at present seen, is due to sub-aerial denudation, and possibly the not greatly varying heights of the parallel ranges might suggest the idea of a plane of denudation.

Be that as it may, the ranges are conglomerate, sandstone, or other hard rock, while the valleys exhibit nothing but crumbing shales, or a nodular sandstone in the upper formation, which seems easily to become decomposed. I stood on the mountain-top and gazed wistfully after these beds, rising one on another, tier after tier, ridge upon ridge, till the eye failed to discern with precision, and the mind was lost in conjecture. But, descending this ridge and crossing the next stream to the north, the Waiwera, matter of interest is found in the fact that the second ridge past the *Productus* bed dips to the north-east instead of, as all the rest do, to the south-west. Its strike is the same, and, with respect to its dip, there can be no mistake, as I observed it several points extending over a distance of four miles.

Returning, however, to the coast line south-west of Roaring Bay, we find the same succession of conformable beds succeeding the *Productus* as occur further west, and these, after an interval of little more than a mile, become again fossiliferous, though the character of the fossils has completely changed, and it is evident that, whether conformable or unconformable, we deal with a different formation. As we go on the coarse sandstones are succeeded by shales, similar to those that overlie the formation we have left behind, with nodules of limestone. Proceeding on further there is nothing very noticeable, till we reach the top of the hill that overlooks Cannibal Bay, where fossil ferns occur in sandstone; and in the cliffs as we descend to the beach occur Oyster, Inoceramus, and Belemnites, not to speak of different species of Pholadomya and others, to assign any name to which would be rash. On the beach of Cannibal Bay no rock is to be seen, but we may presume that the hill on which stands the trig. station (Jacob's Hill) is the representative of such rocks; if so, they would, then, be sandstones, with occasionally a fossil fern; and, passing on to the north side of False Island, we find sandstones with indistinct plant remains, followed by sandstones of a concretionary structure—the concretions very large. These are succeeded in their turn by a coarse conglomerate, which seems to terminate the formation, as the next rock is clearly unconformable.

Thus so far, speaking stratigraphically, we have been dealing with one formation. From the Pilot Station at the mouth of the Molyneux to the north side of False Island, and from the Gorge of Kahiku to the source of the Catlin's River, the beds have been conformable, with doubtful or trifling exceptions. But that such is a seeming conformity only I shall endeavour to show, there being clear proof that unconformity exists at more than one point, though, in one case, it may be more of an inference than a proved fact. But I confess that I was much too rash in writing to you in the dogmatic manner I did, as to my having settled the matter.

The Greenwood Range and coast line for ten miles south of Catlin's River exhibit the rocks as striking in the same direction as those north of the Owake, but the dip is reversed, being to the N.E. instead of the S.W.

From the Catlin's mouth up to the further end of Bloody Jack's Island the beds have a gentle undulating anticlinal arrangement, but beyond this to the S.W. no further anticlinal ridges occur, and the beds dip N.E. about 30°. On the mainland opposite Bloody Jack's Island they seem to dip about 10°, and the sectional views of that place will exhibit the synclinal arrangement of the beds of its north shore. At its N.E. corner are rocks only a little above high-water mark, and these being seen from a distance clearly point to an underlying unconformable formation. There we pick up the same beds and many of the same fossils as are found at Cannibal Bay, and this conclusion is forced upon me in spite of anything I may have written previously to the contrary.

A sandy beach about half a mile in length succeeds the tabular rocks opposite Bloody Jack's Island, where the same rock makes its appearance, this time dipping to the S.W., and, again, a little further along (north), to the N.E. At the point where the beds are quite level the sea has eroded what might have been a small boat harbour but for the presence of a rock that now stands right in the middle of it, striking under the horizontal beds and standing at an angle of 45° N.E., while the cliffs of the indentation on the north side show a dip at an angle of not more than 10°, and that immediately overlying the exposed unconformable bed is quite horizontal, as also, to all intents, is the rock to the south-west. I fear that it cannot be determined whether or not this outlying rock belongs to the *Productus* beds or, at least, to the same formation. From the point last described to the mouth of the Catlin's River the beds seem, on the whole, to dip to the S.W. The strike of this anticlinal ridge is that of the rocks everywhere in the neighbourhood, from 55° to 70° S.E. and N.W. This ridge, if continuous—and I have no doubt of this at least—must occur about a quarter of a mile south-west of the Old Mill and Owake Creek. At the Old Mill we pick up beds dipping about 33° N.E., which contain Pholadomya, and very similar ones to those from the lowest bed in which they are found; and, at a distance somewhat proportionate to that between Cannibal Bay and the lower beds containing Pholadomya, there are the fern beds, from which I have made a very considerable collection. These fern beds are succeeded by a great thickness of overlying strata, mostly sandy shales of a crumbling character, but having an occasional bed of hard sandstone. Before reaching the upper valley of the Oamaru stream the upper part of these rocks is hid from observation by forest and heavy soil, and the junction with the Nugget Point beds, dipping S.W., cannot be satisfactorily made out. But, from the large rocks in the Oamaru Valley, the rocks there ought to dip to the S.W. and to be part of the *Productus* formation. A glance at the accompanying plan will show approximately the position, surface, and extent of the rocks as they dip to the S.W. or to the N.E.; and there it will be seen that the N.E. dip is prolonged in a tongue that deeply indents the otherwise continuous S.W. dip.

Now, the question is, what position do the fern beds of the Owake occupy? Whether, as simple appearances indicate, they occupy a superior position to the oyster and Inoceramus beds of the upper formation (this they scarcely can do), or, as their fossils indicate, a position equivalent to a point half way between the north end of Cannibal Bay and the lowest occurrence of the Pholadomya. Clearly the uppermost beds of the district must unconformably lie on some part of the formation containing Pholadomya, although unconformity is nowhere to be seen. But if the oyster and Inoceramus beds, which form the anticlinal ridge—at least the upper beds of the south-west side of it—if, I say, they pass over to its N.E. dip without unconformity, then these also must do so. On the other hand, we have overlying them a great succession of fossiliferous strata, which, instead of yielding Amuri Bluff fossils, to a certainty give fossils which underlie elsewhere.

As I have before pointed out, the bar of the Catlin's River exhibits the rocks dipping at a high angle in a N.E. direction; whether or not the south-west side of False Island is part of the same beds I could not say, but the nature of the rock on that part of False Island reminds me much of the Nugget Point bed of the *Productus* formation. To sum up: we have one clear case of unconformity, and another one drawn from inference and non-agreement of the character of the fossils included; but, in spite of all this, we must remember that from Molyneux Bay to False Island everything seems perfectly conformable and succeeds in due order, and the same may be said of the section from the Gorge of Kahiku in a parallel direction. Is, then, the interpretation arrived at by the consideration of the evidently most disturbed part of the beds to be depended upon, while a much larger area, in a much less disturbed position, shows little or no evidence of the unconformity I have been contending for? Still I am willing to believe, and do believe, that there is unconformity, and that it does exist where I have indicated. It would be quite unnecessary to prolong these remarks, as sufficient has already been said by me, with the aid of the plan and sections, to convey to you a knowledge of my views and also of the amount of work done.

28th December, 1873.

Since tendering the former portion of this report I have carefully weighed the suggestion made by you with reference to the Nugget Point beds forming a synclinal trough. The inclination of the various beds favours this view, but I cannot say that any of the beds markedly repeat themselves. But there are some facts that look very favourable for the synclinal arrangement of the beds. Thus, beginning at Wiltshire Beach, we have a very hard siliceous sandstone containing fossils of a peculiar character, having a strong beak-like process (a groove on inside of the true shell) on the upper side of the cast. This is associated with a moderately-wide winged *Spirifer*, having a deep and wide groove on its upper valve and under valve radiating from the centre of the hinge; this, with the *Halobia* striated in wavy lines, and a small *Rynconella*.

These beds dip at an angle of about 40° to S.W., as do a part of the beds that form the peninsula of Nugget Point. Suddenly the beds are highly inclined, and the Nuggets are almost vertical; at least approaching 70° of dip. I found no fossils above the actual beds on which the lighthouse stands, till the heavy conglomerate in Roaring Bay was passed. This conglomerate is nearly vertical, and is followed by a slaty sandstone with hard, resisting beds of conglomerate and calcareous rock, pitched very high but yet dipping S.W. Next came about 10 chains of rock, of which I know but little, save that it stands at a high angle; not being fossiliferous I disregarded it. That is followed by the great oyster bed dipping decidedly to the north at, say, an angle of 70°. This is followed by a great thickness of coarse sandstones with indistinct plant remains, and then comes the Ammonite bed, with about a foot of conglomerate and two other bands, which, I must confess, are like the bands that overlie the thick conglomerates on the first descent to Roaring Bay; and if the difficulty of reconciling the *Productus* bed (crystalline limestone) of the southern headland of Roaring Bay could be got over, I would become a convert to the belief that the beds are arranged after a synclinal fashion. One fact more strengthens the supposition, viz., that fossils very like those from the lower beds are found a quarter of a mile further on than the S.W. bluff of Roaring Bay. I must also say that just above the heavy conglomerate at the bottom of Roaring Bay the first chambered shells are to be found, which, if the equivalent of the Ammonite bed, would make the conglomerate the equivalent of the *Productus* beds. Were this so, the locality mentioned as having fossils resembling those from the Wiltshire Beach would reasonably become their equivalent.

This will do very well for Nugget Point, and a section constructed upon facts interspersed in that fashion does not greatly conflict with itself at least. But I confess that if we have beds dipping N., though their inclination should be 80° or even 85°, beds that did at all dip to the south should make an unconformable junction very easy of detection.

Now, in carefully noting the inclination of these beds further south than presently described, what appear to be the same beds that gave the fossils that resembled the Wiltshire Beach fossils became almost vertical, and in the stratification lines you can see them have an inclination in the same bed, sometimes to the north, sometimes to the south, giving it the appearance of a vast sheet of slightly corrugated iron.

The beds that succeed this I could not examine, but further on we find black shales with strings of limestone that gradually pass up into the Pholadomya beds, but whether they belong to the upper or lower beds I could not tell, as the coarse sandstone with streaks of conglomerate might well enough be the Pholadomya boundary. Be that as it may, after examination will probably show that these black shales overlying the *Productus* beds have closer affinities to the overlying formation than to that underlying, and that there is probably unconformity to be distinguished.

Let us now look sectionally at these Nugget Point beds in another locality, say one mile south of the Gorge of the Kahiku to the Gorge of the Little Puerua.

First, we find a very thick conglomerate bed not represented in the Nugget Point and Roaring Bay section, yet probably to be found on the beach of Molyneux Bay. This is followed by sandstones with fossil ferns, coarse grit occurring higher up also containing fossil ferns. This is then followed by shell beds having in their contents a great similarity to the forms obtained at Wiltshire Beach, Molyneux Bay. These beds have the usual strike of the whole series, but the dip, though constantly to the S.W., varies much in its angle of its inclination. This is followed by a conglomerate bed, and then by beds striking N.E. and dipping at a low angle to the S.E. This last bed contains fossils which would place it just above the first conglomerate in Roaring Bay. It therefore occupies its proper position, but this disturbance of its strike and dip is very remarkable. The next rock to the S.W. is the oyster bed, decidedly dipping to the N.E., though at a very high angle. After which, at this particular point, I did not make out the details of the section. But a mile further down the valley, to the S.E., the section may be picked up from the underlying Roaring Bay conglomerate dipping S.W., and run on, without changing to the N.E., through a considerable succession of coarse sandstones, till the top of the range is crowned with a bed of concretionary sandstone with boulders of enormous size.

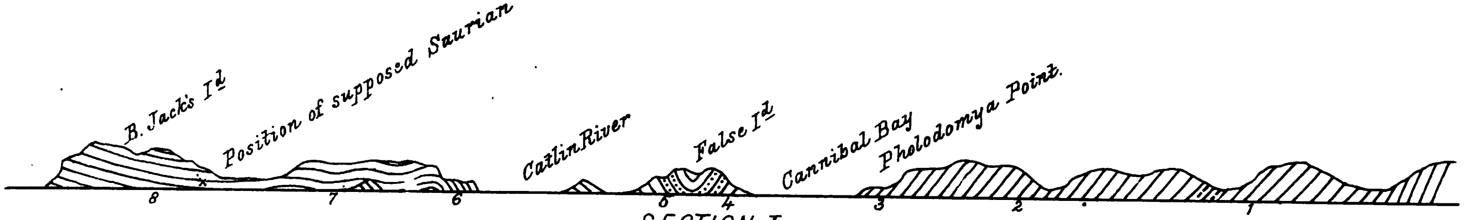
An examination of the same rocks at the Popatuna Gorge will give similar results, save that from the west bank of the Waiwera, after it passes through the Kahiku Ranges, there is a bed of black shale whose position should be under the *Productus* bed, and dipping decidedly to the north. This bed forms a low ridge parallel to the general strike, and continues unbroken, at least as far as the Southland Road crossing, where I last observed it.

Looking at the bearing of this evidence on the whole question, I cannot see how that, in the case of the oyster bed, it should be so continuous in an east and west direction and so limited as to appear on one side of a syncline only, which syncline is probably of very profound depth, if the Wiltshire Beach beds be unconformable, as their low angle would indicate. Yet it is possible, and I have put on record every fact I could think of, so that thereby the truth might be arrived at.

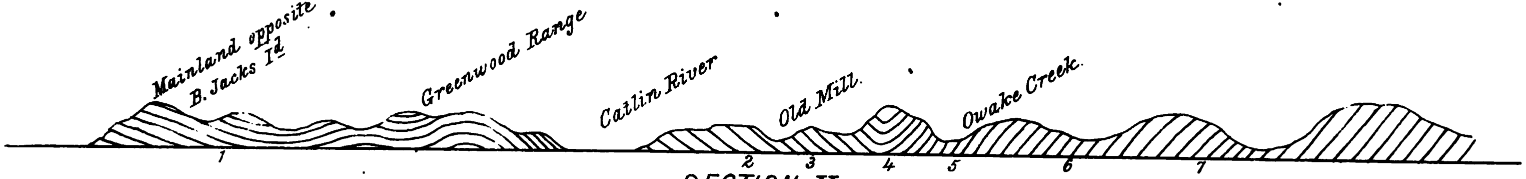
9th July, 1874.

I will endeavour to make as clear as I can what I state below with reference to the geology of the Catlin's River district. In the first place, there can be no doubt that the beds exposed at the mouth of the Catlin's River and on the coast two miles further south are the highest beds in the district, and, from the occurrence in them of *Pecten obovatus*, I have come to the conclusion that they occupy a horizon not far below the Amuri Bluff beds. Belemnites, similar to the fine specimens from Pholadomya Point, occur now and again, and Ammonites also of similar form to those got at the same place, so that a relationship clearly exists between these two points, though the strata in one case are nearly horizontal, and in the other vertical.

I here give a section along the coast, from half way between the Nuggets and False Island to Bloody Jack's Island. The numbers refer to the character of the rock at the points marked. No. 1 is coarse sandstone (grey) overlaid by black shale with calcareous concretions, containing Pholadomya only. No. 2 is a brown sandstone overlying a very coarse grey sandstone, and having distinct plant remains at the point marked "Ferns," where Pecopteris occurs. At No. 3, Belemnites, Ammonites, Inoceramus, Pholadomya, and oysters, are found, and, if I recollect aright, a Panopæa. At No. 4 there are obscure plant remains associated with conglomerates. At No. 5 (the dip here changes from S. to N.) conglomerates with obscure plant remains. At No. 6 are black shales overlaid by bands of greyish green sandstone, in which there are abundant casts of oysters, but no other shells except Pholadomya. No. 7 is the locality from which the chief collection comes, comprising Ammonites, Belemnites, Inoceramus, three species of Pecten, Ostrea, Pholadomya, etc. No. 8 is the mainland opposite Bloody Jack's Island, and, like No. 7, the rocks are black shales overlaid by a bed of cement stone succeeded by coarse sandstone with Pholadomya. These are the only shells, but there are also fossil ferns, which, however, are very rare. As you follow the beds of Bloody Jack's Island south, along the coast, coarse sandstones appear, but I could never ascertain whether or not they pass into conglomerates. Very few



SECTION I.



SECTION II.

To illustrate field Notes by A McKay, July 9th 1874.

plants occur in this section. There are ferns, such as Pecopteris, under the Ammonites, the Belemnites also of Pholadomya Point, and the beds are still the same as at Bloody Jack's Island. Below is a section from Bloody Jack's Island to two miles north of the bridge over the Owake Creek.

No. 8 of section 1 is No. 1 of section 2. From section 2 it will be seen that unconformity may possibly exist on the north side of Catlin's River, between the Ammonite and Belemnite beds and those containing Pholadomya only. Point No. 2 shows the locality of light-coloured fire-clays, with indistinct plant remains in the bank of Owake Creek, opposite the Old Mill. These are, further north, at No. 3, overlaid with green sandstone and Pholadomya only. The dip of the strata, which is here about 55°, becomes, at No. 4, nearly vertical, and here there are conglomerates very like those of False Island; the dip lessens considerably in the bed of the Owake Creek. From No. 5 come the fern collections. At No. 6 the beds dip to the south; they have Pholadomya, and in every respect resemble No. 3. No. 7 is sandstone, very similar to No. 2 of the first section, between which and the Nugget beds in this section I could see no absolute unconformity. I trust you will have been able to follow me in this description.

REPORTS RELATIVE TO COLLECTIONS OF FOSSILS MADE ON THE WEST COAST DISTRICT, SOUTH ISLAND.

BY ALEXANDER McKAY.

To the Director of the Geological Survey.

7th December, 1873.

Sir,

On arriving in Wellington on my return from Otago, I received your instructions to proceed to the West Coast of the South Island, and join you at Greymouth.

I accordingly left Wellington on the 26th November, and arrived at Greymouth on the 28th, where I awaited your arrival till the 4th Dec., employing the time collecting from the Cobden limestone beds immediately underlying, and dark-coloured marks on the banks of the Grey River and Omotumoto Creek. The collections chiefly consisted of Enchinodermata, large shells like Inoceramus, oysters, Waldehemia, Lima, corals, fish remains, etc. On the 5th, 6th, and 7th December I accompanied you to several localities, whence you desired collections to be made; on the 5th up the valley of the Grey as far as the junction of the Arnold River. On the 6th, with the same object, visited with you the Four-Mile, north of the Grey, Point Elizabeth, the Seven-Mile, Nine-Mile, the conglomerates of the Ten-Mile, and fossiliferous beds overlying the burning coal. The 7th was employed in examining the Nummulitic beds in the immediate neighbourhood of Greymouth. I had, on a former occasion, examined this limestone in the hope of finding characteristic fossils, but failed, as on the present occasion, to do so, abundance of Nummulites, and broken corals forming the entire mass. These beds are overlaid by blue sandy clays, in which a few fossils are to be found, but nothing characteristic.

Marsden, 8th December, 1873.

Leaving Greymouth, no sooner had I passed the upper end of the dam (one mile south of Greymouth) than I encountered the first cutting in the blue clay formation, where I observed that it is continuous with the beds that lie above the nummulitic limestone. Passed on till, at gold workings in Sawyers' Creek, near the road, I observed great quantities of nummulitic limestone mixed with the wash which holds the gold, and lesser quantities of the chalky limestones lying on the blue clay bottom.

I gained the following information from diggers: That the low ranges between Sawyers' and Nelson Creeks, where cut through by these creeks, show the nummulitic limestone underlying the blue clays. Along the road, though the cuttings are numerous, stratification is difficult to make out, and the only bearing that I could trust reads N.E. 30°, with a dip of 10°. I passed several heavy cuttings as the road falls into Nelson Creek, and observed that the high level shingle had not even a fragment of locally derived rock. On nearing Saltwater Creek I observed that the nummulitic limestone *débris* increased greatly in size and quantity, probably composing more than one-third of the whole. Reaching Saltwater Creek the blue clays show in either bank, but have nothing in them, nor do they exhibit any clear stratification. Following on I suddenly came upon the Cobden limestone crossing the road about half a mile on the Marsden side of Saltwater Creek. The road cuts through it for about half a chain. The best bearing I could get reads, in the Cobden limestone, N.W. 40°, with a dip of 12°. I could not see the rock actually in contact with its upper surface, but at the distance of one chain the nummulitic limestone makes its appearance, with a strike of about 60° N.N.W., and a dip of 10°. At this point the nummulitic limestone is soft, very sandy, and properly not a limestone, with many black grains in it.

This is followed by blue clay, sandy, in which I could not detect any fossils. At the highest part of the ridge that divides Saltwater Creek from Yankee's Creek, a distance from the Cobden limestone of, say, five chains, marls containing fossils make their appearance, much like those underlying the Cobden stone up the railway line.

From the Cobden limestone I got several sea urchins and one *Scalaria*. The road begins to descend through a cutting, which is again nummulitic limestone, striking N.E. 30°, dip 15°, and this formation covers all the southerly flanks of the range right into Marsden, and at a quarter of a mile from the last bearing given reads N.E. 40°, with a dip of 10°. Section No. 1 is an attempt to show in section what I have been trying to describe.

BRUNNER TOWN, 9th December, 1873.

Started from Marsden, taking the horse back to the Eight-Mile Creek. Crossing New River at Cockbulla Creek, saw blue sandy clays, but could not make out the stratification. At the crossing at Maori Creek Township found the beds distinctly stratified, the strike being N.N.E. 10°, dip 37°, the rock being fine sand of a greyish blue colour, full of fossils like *Tellina*. Immediately on crossing I observed some great blocks of granite, one being 6 or 7 feet in diameter. I also noticed that the wash in the neighbourhood of Italian Gully had a very subangular character, and that as the lower ground was reached it was more rounded. From this I took the track that would lead furthest in the direction of the coal formation. In the head of Lancashire Gully got a *Turritella* in a limestone concretion. On the N.E. side of Italian Gully the beds have become decidedly sandy, and strike N.E. 20°, with a dip of 35°. This dip, a little further on and a little deeper in the formation, is increased to as high as 50°, the rock being a coarse, soft sandstone without fossils. Near the peak of Mount Riley coarse sandstones and conglomerates with fossils make their appearance. Very coarse conglomerates, in no wise cemented, but as loose as the surface wash, occur on the spurs of Mount Riley. Some of the boulders are 12 or 14 inches in diameter.

GREYMOUTH, 11th December, 1873.

Yesterday I collected at the point where you met Mr. Simpson, and got some good specimens of *Cardium*. Got fossil plants on both sides the river. From a large detached block of sandstone from the bed which overlies the coal on the Brunner Mine side I got some very good leaves showing the venation very well, and that long, narrow leaf attached to a midrib like a fern that is found in the lower Trelissic beds in Canterbury, and another very peculiar plant that I have only seen from Shag Point.

12th December, 1873.

Coal Creek is unfavourable for seeing anything, as wherever rocks occurred they were but repetitions of those I had already seen, the creek running nearly along the strike of the beds. If I descended I found lower beds make their appearance, and if I went up stream these beds got covered by beds higher in the formation. The bed rock at the gold workings is the blue marl that overlies the Island Sandstone, and in following the creek down these marls gradually became concretionary without much apparent difference in their composition, which again gradually changes in texture and colour to the Island sandstone. In the upper part of these concretionary beds I got two specimens of *Echinoderms*, which are very like those from the Cobden limestones.

SAWYERS' ARMS, 13th December, 1873.

Following the creek which crosses the A.K. line, I noted, at the point of crossing, that the bed rock was the blue micaceous sandy marl. This, the second creek after taking the A.K. line, I followed to its source, and found nothing but the same soft micaceous marl or sandstone, harder indeed than the crumbling marls on the banks of the river, but yet not greatly different in appearance, and nowhere resembling that crumbling character, because always kept moist by the damp of the bush.

Following the range along which the A.K. line runs towards Rata Peak, all I could see was composed of the same soft micaceous marl, but on the higher hills it became fossiliferous, and contained fossils similar in character to those found in the black marls underlying the Cobden limestones. I got two species of *Pecten*, one *Leda*-like shell, a *Nummulite*, and those peculiar fossils that are best described as a long, tapering cone, deeply striated latitudinally. One particular hill overlooks a circular basin of great depth, along the S.E. end of which I could see the middle tertiaries of Mount Reilly and Mount Fox striking, while its N. and N.E. sides were bounded by the coal range or old rocks, and a spur of the range on which I stood closed in its N.W. end, having two outlets, one to N.W. by way of Racecourse Creek, and one by a branch of Stillwater Creek. I had not travelled far beyond the peg marked "A.K. 132" when I encountered, in one of the gullies, a hard, coarse sandstone, brown when decomposed, coarse conglomerates similar to that containing fossils occurring in Mount Reilly. In the same creek I picked up a conglomerate composed of coal in rounded pieces, the matrix being micaceous sandstone of a grey colour. I also picked up a lump of what seemed to be nummulitic limestone.

14th December, 1873.

Again went up the A.K. line till the junction of the coal reserve and another line which runs up the first creek. I followed the creek to several of its sources. I had not gone far up when the rocky bed disappeared beneath a muddy bottom derived from the neighbouring subsoil, and all search for coal in such localities was in vain. Pushing on, however, I ran one branch out on the gap, and following another to a like source a little further to the W., the next and larger branch struck to the S.W., and, after some distance, ran into the range described in yesterday's letter, the sources of which I had seen as I went along the A.K. line. Returned along the coal reserve line, finding rock on the last spur before the line reaches the creek, the same as that in the creek bottom at the crossing of the A.K. line.

GREYMOUTH, 15th December, 1873.

Took the A.K. line this morning. Observed that wherever the bed rock is visible it is invariably the grey or black marls that overlie the dark blue marls lower in the series. At several points I got fossils in proof of this; the same *Pectens*, *Limas*, *Leda*, *Echinoderms*, and others, all from the stone-coloured marls which underlie the intensely black which succeed in downward succession the banded sandstones seen beyond the quarries. I got at last to the spot to which, by your directions, I should have reached some days ago. Here I found great masses of a coarse, micaceous, grey sandstone (brown where decomposed) completely choked the watercourse with small pieces of coal lodged on such little shingle patches as occur. I found the bed rock to be the same soft, dark or grey crumbling marl, as proved by the fossils, that underlies the Cobden limestones above mentioned. But whence came the great blocks of micaceous sandstones? Nowhere was that to be found *in sitû*. The banks of the creek were often composed of angular *débris* mixed with clay. I soon observed that much of the sandstone contained streaks of coaly matter, sometimes as a coal sand, and at other times being rough enough to be called a conglomerate, some pieces thus included being 1½ inches diameter. I went up the creek, and some distance up found beds of this sandstone, and, in one place, the bed whence this coal conglomerate comes.. At this point where I observed it, it was not more than six inches thick, and the coal pebbles small. I, however, saw blocks in the creek bed that would prove that this coal conglomerate sometimes reached a thickness of a foot. Other beds of the sandstone became coaly, so as to give it a dark colour and a flaggy character, but nowhere, except in the one particular bed, did it approach the conditions of a conglomerate. These hard sandstone bands were interbedded with layers of soft marls, which, being removed, have caused great slips of the harder sandstone, and this accounts for the blocks in the creek, as well as for the smaller angular pieces in the banks beyond reach of the creek. I got from here one or two *Echinoderms*, a dicotyledonous tree leaf, some *Pectens* and other shells as found along the railway cuttings. As to the position which these beds occupy, there can be no doubt that they are intermediate between the beds that immediately underlie the Cobden limestone and the blue micaceous marls overlying the Island sandstone, into which the lower beds gradually pass. The coal conglomerate and sandstone beds lie all along the western face of the range to the east of the Omotumoto Creek, and, as the gradient of this face of the range and the dip of the beds (15°) is not greatly different, it occupies nearly the whole of the surface; and the sources of the Racecourse Creek, on the east side of this range, have masses of sandstone and occasional pieces of coal conglomerate in them, and fragments of coal finding their way down the creeks will account for such pieces as have been picked up in them. I have been informed that the pieces of pure coal are much larger near the north end of the range, and that the masses of sandstone are there equally as large. That this is true the strike and dip indicate, the strike being N.W. 10° at this point in the left-hand branch of the Omotumotu, which, at an equal elevation or horizontal line, would just bring its outcrop where my informant describes it.

DARKIE'S TERRACE, 16th December, 1873.

Commenced work at the first bare scrap of rock, but found fossils few, a few specimens of the sea urchin, of oblong shape, being all I could get. Nearer Point Elizabeth was more successful, but could get no *Pecten hochstetteri.* I found a good specimen of that shell which you said was new, and of which we got a specimen the day you rode to the Ten-Mile. Got many fine instances of that fibrous and radiated coral which occurs in the Oamaru and Weka Pass limestones, but never seen so perfect as here. Looked for greensand bed, but, except a thin bed about a foot thick and not rich in fossils, saw none.

17th December, 1873.

To the other side of Point Elizabeth. Only able to distinguish five kinds of shells, and no teeth nor remains of fishes. Made a great collection of *Echinoderms*, one being nearly equal in size to that you got before going to Reefton, and superior to it in its markings. A great number of specimens belong to the form that may be described as a flattened hemisphere. I did not get any of the large *Inoceramus* found in the white stone at Cobden, but another shell occurs which I would as much incline to call *Inoceramus* as oyster, and this, with two varieties of oyster and the *Terebratula*, are all that I saw.

On the face of one of the large masses of rock is the finest specimen of the radiated seaweed I have ever seen, the texture of the plant between the ribs being easily made out, and the stems near it have small fibrous stems or feelers attached, like the stalk of some *Pentacrinites.*

At Point Elizabeth the Cobden limestone seems to thin out, and never reaches the actual point, the limestone, such as it is, being undoubtedly the upper fucoidal beds, greensandish and full of the stems of seaweeds, and with an abundance of oysters and sea urchins not known in such quantities in the real white limestone. The banded sandstones that overlie the black marls at Cobden and Greymouth are, at Point Elizabeth, succeeded by a considerable bed of pure greensand, and then succeed the fucoidal limestones, the Cobden limestones having shared the fate of the coal conglomerate and its associated rocks on the range east of the Omotumoto, which do not come much north of the Grey, if so far.

In going along the beach to Greymouth I picked up a piece of slate with several specimens of the fossil *Annelid* common to the secondary rocks of Canterbury, which must have come from the slate beyond the Twelve-Mile, and possibly such were the fossils Mr. Davis saw.

TEN-MILE CREEK, 19th December, 1873.

On 18th left Greymouth, and arrived at the Nine-Mile Creek, where we saw so much ironstone when you and I visited the Ten-Mile. Here I employed the remainder of the day, as I had spent a little time in examining carefully the cement stones (for undoubtedly they are such) of the Nine-Mile Bluff. I could, however, detect nothing that would pass for bone, which was all the more tantalizing that the rocks looked so promising. While on the subject of the resemblance of the rocks to others of the same age in other parts of the colony, I may say that the lower part of this series bears a much stronger resemblance to such rocks as do not yield Saurian remains, and yet are undoubtedly of the same age as those that do. I refer to the absence of these remains in the rocks at Shag Point and the Malvern Hills, though the evidence in either case is negative. I can see that the fossils differ much in character, even though the horizons be not greatly removed. Thus, at the Ten-Mile, the fossiliferous beds that overlie the coal, though carefully searched, show not the least evidence of *Pecten hochstetteri*, though we cannot doubt that it existed in rocks of an equivalent horizon as at the Nine-Mile Bluff. But to confine myself to facts. I got from the ironstone boulders a variety of leaves, all of which have a strong resemblance to the flora of the Shag Point, a fact that you will not fail to observe in the collection from the Brunner Mine, where the resemblance to the Shag Point is most marked. I also was favoured with a sight of a very beautiful fossil shell, of which I spoke to you on your return from the coal seams up the Ten-Mile. Your guide tells me that he mentioned to you having seen the fossil sticking in the cliffs north of the Nine-Mile. It is an oyster, identical in species with that of which Dr. Haast wrote to you in the spring. I have not been able to obtain it. It seems rare. I also collected a few specimens of *Cardium* near the accommodation house.

19th December, 1873.

Collected from the beds overlying the burning coal, and found a great variety of fossils. Very successful among *Echinoderms*, but they are exceedingly tender, from the rock being decomposed owing to burning coal. I had the good fortune to light on a veritable *Ammonite* in this particular bed of considerable size. Search for another was fruitless. In no locality do the cretaceous beds exhibit such a number of species from their lower beds than here. But I miss the black oyster and the *Cucullœa* of the Waipara. This absence is made up by *Fusus* and *Turritella*, and a variety of shells got in the Green Island beds.

Saw the junction of this series with the old rocks at the Twelve-Mile. The underlying unconformable rocks I found to be silky slates and green sandstones, of which a considerable quantity enters into the composition of the underlying conglomerate of younger age. These lower rocks are much jointed, curiously contorted, and decidedly brecciated at their junction with the conglomerates that overlie. They are immediately succeeded by a coarse conglomerate, and the denuded surface on which it lies is now comparatively in a horizontal position, as may be seen from the long section of this overlap visible at low water. Interstratified with the lower part of the conglomerate is a thin bed of a micaceous sandstone, not unlike that underlying the coal at the Brunner Mine, and this is again followed by coarse conglomerates, some of the stones measuring

18 inches in long diameter. Again, between the conglomerates a bed of coaly shale intervenes, and at 15 chains from the junction with the old rock occurs a bed of coal, whose thickness, from the state of the tide, I could not make out. These are overlaid by sandstones, followed by more conglomerates, which contain large concretions of ironstone, and, in some places, sheets that appear almost as a continuous bed. This ironstone is fossiliferous, and contains leaves like those got at the coal mine. You are familiar with the fireclays and sandstones that divide this conglomerate from the great mass of conglomerate which underlies the brown coal of the *Cardium* beds.

20th December, 1873.

I secured the large oyster of which I gave you a description in my last, and am sure of the bed whence it came, as I found two others sticking in the cliffs that just overlie the brown coal at the Ten-Mile Creek. But they are so deeply buried in the face of the cliff as to defy extraction without a ladder and great labour, and even when got, from the matrix adhering, could not have the appearance of the specimen I have just had the fortune to secure.

21st December, 1873.

Storm at sea still raging, and sea so high as to prevent my getting along the Nine-Mile Bluff to collect. Added to the collection from the beds at the burning coal, also from the black marls that overlie what I call the lower coral bed, to distinguish it from the coralline nummulitic limestone of the formation overlying the Point Elizabeth beds, which it very much resembles, and, but for the absence of the nummulite and its absolute conformity to the underlying and overlying rock, must have shaken the idea that it belonged to the formation containing the coal. This, however, independently of the evidence given above, could not well be maintained in the face of the further testimony of the *Cardium*, *Echinoderms*, and several other forms common to the lower part of these beds. As for the other blue or black marls that intervene between the Nine-Mile and Point Elizabeth—though it is true, as you say, that the section cannot be seen throughout—there is not the slightest ground for the supposition that the intervening valley contains a younger formation other than the recent and pliocene drifts. Nor can it be contended that the black marls there are themselves the younger formation, as they succeed the coral rock in like manner as they do in the syncline between the Ten-Mile Creek and the Nine-Mile Bluff, and they unquestionably, without any break, pass under the banded sandstones that underlie the Cobden limestones and Point Elizabeth beds.

While the tide was out I collected at the Nine-Mile Bluff, but found the fossils most difficult to get, especially the *Pectens*, and I may say that I cannot find *Pecten hochstetteri* at all. Two *Pectens* are to be found in the rocks of the Nine-Mile Bluff, one of which is undoubtedly a variety or another species of the same kind as the small-eared *Pecten* concentrically striated, and found in the pebble bed of Dr. Haast's Amuri Bluff Report. It is larger, less oblong in shape, fuller in the ears, but yet decidedly a *Pecten* of the same generic affinities. The other is a small *Pecten* found in both the Waipara and Amuri Bluff, about half an inch diameter, and ribbed strongly in proportion to its size. I succeeded in getting one or two good specimens.

In the evening got some very large *Teredo* from a block near the accommodation house.

22nd December, 1873.

It is true that at Point Elizabeth there is no great variety of shells, and no trace of *Pectens*, save a small-ribbed, unequal-eared one with the ears at an angle to the median line of the shell. Yesterday a miner belonging to the claim with the water-wheel for pumping went up the Nine-Mile in search of coal and ironstone. He says that on passing the peak on which the highest burning coal is, the Nine-Mile Creek runs through a flat, and, further, that they passed one series of conglomerates, then soft shales (they mean the shales of the Twelve-Mile), and then came to another lot of conglomerates, which they failed to see the end of. Ironstone boulders were strewn along the creek bank as far as they went, which was to be expected, as they did not reach the iron in the bed rock, though, from their account, they could not be far off it. You will observe that the conglomerate does not lessen in thickness till some distance south of the Nine-Mile, and, further, the strike of the coal outcrop after leaving the Ten-Mile must be nearly E., as, from the account of my informants, they must have been some miles beyond the point equal to its outcrop in the Ten-Mile.

DARKIE'S TERRACE, 24th December, 1873.

Left the Ten-Mile at noon on 23rd, coming along the Blackboy Terrace, south of the Seven-Mile. Found nothing but the small *Lima* and some fragments of a spiral shell and a sea urchin, all of them satisfying me of the identity of the beds with that portion of the black marls that underlie the Omotumotu sandstone and coal conglomerate, though perhaps, strictly speaking, the evidence is not sufficient. But this supplementing the stratigraphical evidence given in my letter of 22nd instant can leave no doubt that they are really as there described. I got very perfect specimens of the coral I have already mentioned.

GREYMOUTH, 28th December, 1873.

On account of the weather I have had to confine myself to an examination of the beds that occupy the flat ground to the north of the Grey, between the coal mine and the Cobden limestones, where we first saw the blue marls. I was led here by an account of leaves having been found, but they turned out to be faint impressions of slender seaweeds. The same beds at this spot contain seaweeds whose stems are three or four inches in diameter, composed of hard crystalline lime, which, but for the want of bony structure, would be very difficult to distinguish from fragments of ribs. I got also some shells, one or two sea urchins, and a crustacean claw, very distinct, and the peculiar fossil which distinguishes the black marls which underlie the Cobden limestones and found in almost every part of those beds.

REEFTON, 1st January, 1874.

After having seen the Nine-Mile Bluff, the resemblance between that and the Island sandstone is most striking. The conglomerates of the Ten-Mile are far from being absent, or only represented by equivalent sandstones, seeing that large masses of conglomerate occur in or near the Island fault, one piece I observed in passing in which the pebbles might be two or three inches in diameter. Next the gravels, which everywhere after leaving Mount Buckley cover the low ground, seem divided into two portions, the upper blue in colour and having no clay mixed with it, the lower of a brown yellow colour and mixed with clay of the same colour. In the upper shingle beds silt and fine sand occur. I did not observe any such in the lower, as what sometimes seemed to be beds of finer material may have been the underlying tertiary rock. Saw masses of brown coal in bed of main branch of the Grey, and after that nothing of consequence till within a few miles of Square Town, where a bold cliff is exposed on the spur of a range to the east of the valley. What the nature of the rock here was I could not, from a distance, determine, but, looking to the stones of the same colour in the wash, should say that it was a conglomerate. When the river is last crossed before reaching Square Town its wash is nothing but granite boulders, and, as you are aware, the road is formed from Square Town to Reefton, such granites might be expected to form a large percentage of the shingle used in its formation. Such is not, however, the case, the preponderance of slates and sandstone over granite being most striking, though granites are not absent. This shingle looks compact, and has an appearance of consolidation seldom seen in a recent shingle bed. I at once set this down as the conglomerate of the ranges to the east. This was further confirmed as we neared the saddle, where finer grained beds began to appear, forming, on the south side of the saddle, a synclinal trough. The dip of the beds having hitherto been to the N., and from this point changing to an opposite direction, I was very curious to know if I could find any fossils in these beds, which, as you come down the cutting from the saddle, exposes conglomerate beds composed of all rocks. A number of beds of sandy clay crop out from beneath that, after which a bed composed almost of mica, slate, and quartzite, without the slightest fragment of granite in it. This is the last rock to be distinguished before reaching the bed of the Inangahua, where granite again predominates in the recent waste. On arriving at Reefton I received the following instructions, directing me where to collect fossils from the older rocks in the district:—

Memorandum for Mr. McKay by Dr. Hector.

"WESTPORT, 20th December, 1873.

"I enclose a rough sketch of the Reefton country, showing the position of certain fossiliferous beds. Liverpool Davie's Gully, of which I had heard as the locality of the fossils sent to Christchurch, is an alluvial digging close to the town, and contains only rolled fragments in the wash that have been brought down the gorge of the river. I have laid out some very fine specimens, the casts being very clear, owing to the calcareous matter having been removed from the matrix. I daresay you will find many more, and have asked the digger who is working the claim to show the best boulders he has come across. The rock with the fossils *in situ* strikes across the district from S.E. to N.W., as shown in the plan, forming a very bold feature. Go up the main branch of the Inangahua for three miles, or one mile past the Wealth of Nations battery, and you will find a rocky point above where the track to Rainy Creek crosses the river, and opposite to a hut. This point consists of blue and grey limestones and red quartzites; dip, 50° to 70° to S.W. The upper bed is a blue madrepore limestone, and the fossils are in small beds with quartzites between. The limestone weathers red, and when in that condition fine casts can be got.

On the whole the fossils resemble those from Mount Arthur more than the Trias beds, and are very like the Gympie Creek fossils from Queensland. They are probably Devonian, but this must be settled after you have made collections. Looking up the valley, the same beds are sure to form the south-west flank of a high granite mountain; and in the opposite, or north-west, direction I traced them through the country to Murray Creek. They seem to underlie and to cut off the auriferous formation, but I wish you to look closely to this point. The auriferous rocks are grey sandstones and flaky slates, with mica and pyrites, and often tufaceous. Those beds weather very freely, and have white, dull, powdering surfaces. The sandstones are sometimes gritty, with sub-angular grains of quartz. In some cases they fracture like diorite. Their strike in the best reefing ground is from N. to N. 30° E., and the dip changes several times from N.W. to S.E., and varies from vertical to 45°. They are thus nearly at right angles to the fossiliferous beds, and probably very much younger. I could not find any fossils in the auriferous rocks, but hope that you may do so. They are well exposed in the gorge of the river up to Black Point, along the track, and again in the bed of Murray Creek, so that you will be able to examine them closely. The junction between the two formations is obscured by the coal series, which comprises (*a*) mica shales with coal, (*b*) sharp quartzose grits, and (*c*) brown sandstones. These are well exposed in the upper part of Murray Creek and in the tributary creeks of the auriferous range. The Devonian beds appear to rest on the granite, as in the enclosed section.

"Take your time and examine the district well, and, if possible, make out what becomes of the fossiliferous beds towards the north. Boatman's Creek reefs are in the same formation as those at Reefton; but further north, at Larry's Creek and the Lyell, the formation and reefs are very different, and, I think, must belong to a separate belt of ground beyond the granite.

"At the Inangahua crossing (where there is a punt) you will get a good section. The lower coal sandstones are covered by a hard, blue limestone, exposed in the road cutting on the west side of the river, and in which you should find something.

"At Christie's, in the Buller Valley, you will find the older calcareous and marl beds resting direct on the old quartzites and slates, but further down, at Coal Creek and at the junction of the Orakahu, the upper coal and brown sandstones intervene (see section). At Grainger's Point a porphyritic breccia crosses the river, followed by hard, green sandstones, and these by thin bedded sandstones and shales with pebble beds. The beds are red and green in colour, and I have only found a few plant fragments, but they are very like the Upper Trias beds (or Lias) of Southland, which contain short-winged *Spirifers*. There is a good section of these beds opposite to Hughes's accommodation house, where there is a canoe that you can cross in. At the point below, these beds are overlaid

> (unconformably) by conglomerates with a sandy matrix, which, on the north side of the river, form the Blackwater Ranges. The Lias beds again rise, and are well exposed in an old sluicing ground near the mouth of the David River, which comes down from Mount William. The pebble beds are much thicker here. The old sandstones then continue on the north side to below the Blackwater rapid, where the red Lias beds again show. The south side of the river is mostly upper conglomerate however. In the long, straight reach before reaching Hawke's Crag the junction is clearly shown with the red beds and the coarse conglomerate formation, which now form lofty ranges with precipitous faces on both sides of the river as far down as the Big Oweka River, where, after a narrow strip of mica schist, the granite commences and continues throughout the gorge to the open country round Westport.
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> "You will perceive the necessity for a careful collection from the different beds above referred to, as the section is one of the most important in the district. Take several days to it, as there are plenty of places to stay at and canoes to put you across the river at various points. The boats that go down the river will carry your collections down to Westport for you."

REEFTON, 31st December, 1873.

Went back to see if fossils of any kind were to be found in these younger beds, but, save some indistinct plant markings, did not succeed. I found, however, a most curious substance in the upper beds near the top of the range. It is a white substance without crystallization, but with a tendency to break into tabular masses, as soft as tallow, which it much resembles.

Near Reefton, on the track leading to Black Point, found, in the auriferous rocks, something like the forking branch of a fossil tree.

1st January, 1874.

Went across the river in the morning, and worked out what stone there was in Liverpool Davie's Gully. In the afternoon went along to Black Point and up Murray Creek, carefully looking for fossils, but without success. I noted a great resemblance between these auriferous rocks and those that underlie the coal measures at Brunner Town, not merely in the character of the slates, but in the curious diagonal cleavage.

2nd January, 1874.

Removed to Black Point, and went up the Inangahua to the fossil bed, following the beds further up the river (that is, running the section downwards). Found fossils over a width of perhaps 30 chains, the lower beds having but few varieties of shells, and in these the peculiar shell of Wiltshire Beach, Molyneux Bay, predominated. Made what collection I could. Observed the *débris* brought into the river bed of the Inangahua by Garvy's Creek, which consists mostly of the silky slates of the auriferous rocks, and that if the auriferous rocks occur at its source there must be positive unconformity between them and the fossiliferous beds, or else the fossiliferous beds are interbedded between two separate sets of silky soft slates. Found it very difficult to get good specimens from the beds at the Black Rocks, as few shell masses were sufficiently decomposed, and the unaffected rock did not show shells clear enough—in fact, when fractured, seemed without fossils.

3rd January, 1874.

Collected from limestone at the Black Rocks, and got some very fine specimens of the corals so plentiful there. Could not, however, succeed in getting good shell collections, and, after getting what I could, determined to try the slopes of the range, along which the beds have here outcropped. In doing so I necessarily came to the creek north of the Black Rocks (as the fossil beds are called), and in the face of this creek, just below the fluming of the water-race, I got some very good fossils. Following the creek, fossil blocks became more frequent as I went up.

4th January, 1874.

Visited the Rainy Creek quartz mine. Rainy Creek enters the Inangahua two miles above the crossing of the fossiliferous beds on that river. Garvy's Creek, which comes from the east, may be a good mile above the fossils. Pushed on to Garvy's Creek, and, as before remarked, the material brought down by it is derived from the auriferous rocks, which, as the bed rock could not be seen, was very difficult of explanation. Went on, and entered the mouth of Rainy Creek, and had not passed far up it when we found the bed rock striking N. and S., dipping 50° E., the rock being the silky slate of the auriferous series. No further rock was seen till a distance of 30 chains from the mouth of the creek, where I again found the bed rock striking N. and S. The rock was the sandstone of the spur beyond Black Point, viz., coarse sandstone with sub-angular grains of quartz. Twelve chains further up the creek the strike was N.W. 30°, dip 85°, and at an estimated distance of 50 to 60 chains from the mouth of the creek found the rock striking S.E. 10°, dip 45°.

At the lower part of the alluvial gold workings a fossil bed crosses the creek, striking S.E. 10°, dipping 45°. From this rock I could not get any fossils that could be recognized, but thought I could see fragments of what we must call (provisionally, at least) *Productus.* I could get no shell sufficiently perfect for recognition. The rock in every respect resembled the coral bed at the Black Rocks. The course of Rainy Creek, from its junction with the Inangahua to this point, is about N.W. Here it turns round to the S.W., and its source heads from the S.E., the first part of its course being from a point that makes a straight line with the mouth of Garvy's Creek.

The next rock, as we follow up the creek, is not more than a few chains above the last described. This has fossils also, but they cannot be recognized. The rock is black, and such impressions as are at all distinct remind me of the *Cardium* of the coal measures. The strike of this rock is S.E. 5°, dip 80°. About half a chain of it is exposed, and its upper part is soft shale full of sulphuret of iron, which is itself very loose and incoherent. This is overlaid, apparently unconformably, by coarse grits, that at once bespeak the presence of the coal measures. These coal measures are capping the hill tops in tabular masses, and this patch on the north side of Rainy Creek strikes S.W. 75°, dip 6°, so that you will observe that it is almost horizontal. This is exposed along the track for four or five chains, when we suddenly find shooting up through it a blue or black indurated shale, much broken, and all coated with sulphide of iron. This rock is fossiliferous, and strikes N.W. 10°, and dips 80°. I am inclined to regard this as the oldest fossiliferous rock yet found in this district. The fossils are decidedly distinct from those at the Black Rocks, and there is no appearance of casts with the beak-like process so plentiful in the cherts of the Black Rocks. I believe these particular beds and fossils to be older than the rest, and probably Silurian. But I believe I have also got in the same beds the chambered portion of the straight Cephalopod found in Lower Devonian rocks. The specimens in question are not *Encrinites,* being divided as by partitions, they will not part in sections like *Encrinites,* are rounded at the taper or distal ends, and want the radiated structure of the *Encrinites* belonging to this formation, many of which are found alongside, but always of less diameter, the fossils in question being usually more than ½ inch in diameter. I got in these beds a large *Productus,* say 2½ inches across the wings, and a decidedly Silurian *Orthis,* if those described in Lyell are characteristic.

You will observe by the bearing given that these beds are again dipping W., and that it is just possible that between these old fossiliferous rocks and the first fossiliferous bed mentioned we have a portion of the coal measures entangled, which the lateral movements of the old rocks may have set on edge, as we find it. Passing yet up the creek, we find hardened siliceous shales and sandstones overlying coarse, brown sandstones, and standing at an angle almost vertical and striking due N. and S. This continues up the creek for about five chains, when the old rock again comes in, both it and the coal rocks standing vertical at the point of junction. Beyond this, to the westward, I could not make out with certainty either the strike or dip of the rocks, but I think they are the gold rocks, and that they dip to the W.

From this point Rainy Creek strikes away to the S.E., and, after passing through a spur of old rock, runs along this syncline of the coal beds, or rather at an angle across it, having the high ridge with the quartz reef on the S.W., and to the N. and E. the rocks already described. Horizontal coal measures cap all the ranges S.E. of Rainy Creek, and partly also N.E. of it. From the vertical coal beds at the deserted township I got dicotyledonous leaves, and from a brown sandstone found as boulders in creek. Got the *Cardium* of the coal at Brunner Mine, and two others common to the Ten-Mile North Beach.

5th January, 1874.

Collected fossils, and in afternoon returned to Black Point. In returning I observed, south of the mouth of Garvy's Creek, a section of the auriferous rocks clearly stratified and dipping to the E., the strike being N.E. 10°, dip 50°.

I must defer description of Murray Creek and the fossils (as I suppose them to be) of auriferous rocks, as the mail is closing. The fossils are circular, disc-like spots of earthy calcareous matter contained in the silky slates, sometimes with a cervical core, and radiated from the centre. I thought them at first structural to the slate, and now think them to be fossils.

8th January, 1874.

I will re-state the main facts of my last, and add such as I have collected since.

The Rainy Creek quartz mine is situate in a separate division of the auriferous rocks from the Reefton district, having a dip at the mine to E.S.E., as shown in the accompanying map and sections. These (the auriferous rocks) form an anticline at about thirty chains from the mouth of the creek, and further on the fossiliferous beds appear dipping to the E., and capped by coal measures. Beyond this you would scarcely understand what I meant in my letter of 6th, but since then I have studied the same rock elsewhere. At the Black Rocks the madrepore limestone, as there seen, is overlaid by a similar rock, only the fossils are smaller and the matrix more argillaceous. This should be overlaid by dark slaty shales, of which the lower part is a blue slate, full of long-winged *Spirifer*, some of gigantic size. The cast of one specimen is 5 inches in width. This upper madrepore limestone, then, is the rock which so much puzzled me in Rainy Creek, and the shales which I then mentioned as Silurian are indeed the overlying shales and slates mentioned above; and, as iron ore occurs in the same beds east of the Inangahua, the sulphuret of iron there described does not of necessity belong to the coal series. The shales in Rainy Creek, where exposed, dip at a high angle to the W., and undoubtedly contain, both there and elsewhere, the chambered portion of an orthocerate Cephalopod, together with a great variety of shells, many of which are common to the Nugget Point beds, but also many that are new and strange to me. The coal beds which cap both the auriferous and fossiliferous rock suddenly dip at a very high angle, forming a deep synclinal trough, obscuring what would otherwise have been the junction between the fossiliferous and northern division of the auriferous rocks which succeed the coal and dip away to the W.; the deep trough of the highly-inclined coal beds running, as described, to the source of Rainy Creek, while its northern prolongation brings it as far as Cement Town—at least, that is exactly along the line of junction between the fossiliferous and auriferous rocks.

6th January, 1874.

Went up Murray Creek to Cement Town, and found in the lower part of the creek the rocks dipping to the E., afterwards to the W. Just as you pass out of the gorge of the creek I observed a great change in the character of the rock, marking, I suspect, that here we have an outcrop of the fossiliferous beds, which subsequent observations have tended to confirm.

The rocks in question are dark shales mixed with quartz and flesh-coloured cherts, with a remarkable bed of deeper brown elsewhere identified. These cherts, dipping at a high angle to the W., gradually become vertical, and at the point where my last observation was taken dip to the E.

Wishing for the present to avoid all contact with the coal beds, I took the track that leads over into Lanky's Gully. Ascending the hill I found, about half-way, grey shales with dicotyledonous leaves dipping to the W., and immediately on passing the watershed which divides Murray Creek from Lanky's Gully I found the same beds highly inclined, and dipping to the E. Then came light-coloured cherts full of dicotyledonous leaves, some of them of great size and well preserved. Then, as you followed down the track, the dark rock which puzzled me at Rainy Creek, and, lastly, the auriferous rocks dipping W., which, with an exception (and that might be a false observation), continued till I reached the foot of the spur.

7th January, 1874.

Went to Lanky's Gully, and found the auriferous rock occupying its bed for a short distance above the infall of the first branch to the N. These auriferous rocks have here a dip to the W. Ten chains higher up I found the cherts of the fossiliferous series dipping E., and, close by, the upper madrepore limestone also dipping E. Five or six chains higher up I found the black shales and blue slates before described standing nearly vertical, and eventually dipping W. Just where the dam lifts the water-race from the creek bed is the great madrepore limestone with the corals, this time of great size, some 12 inches in diameter. From this you will see that the fossiliferous beds form a syncline, and that necessarily the auriferous rocks must under- or overlie the fossiliferous unconformably.

I wished to run the section so far downwards as to prove its presence below the coal at the head of Murray Creek, and, for this purpose, pushed as far up the creek as I could, taking, at its second division, the southern branch, which I followed to the far top of the range through a great thickness of flesh-coloured brown and grey cherts, the last yielding fossils almost at the top of the range, which, at the very top, has the usual capping of coal strata, this time being a coarse quartzose sandstone, almost a conglomerate. Found that the main source of Lanky's Creek was away to east of where I stood, and that in following down the slope of the range a little to the east the cherts again showed from under the coal rock. From the precipitous character of the country I guessed that the cherts must continue for at least another mile, a fact which we shall afterwards see is of great importance when considering the relations of the eastern wing of the auriferous rocks. Leaving my stand-point, after having taken the bearings of the prominent features of the country, I followed the northerly spur, and dropped into the middle and main branch of the creek (which here, as elsewhere, showed not a fragment of the auriferous rocks), and after some difficulty gained the locality where I left the main branch, and so returned to Black Point, bringing with me some specimens of a fossiliferous crystalline limestone, which, when polished, will show fossils, I have no doubt, of a peculiar character. I could not find this rock *in sitû*, but suppose it to be interstratified with the chert beds that underlie the madrepore limestone. But of this there is no surety.

10th January, 1874.

On 8th January I collected in Lanky's Gully, and the collection is in many respects superior to the Nugget Point collection, and I know will delight you. On the same day I examined closely the auriferous and fossiliferous rocks in Lanky's Gully, in the direction of their junction on the north side of the fossiliferous band, and found a junction such as is seen in section B—B of the small map. I got bearings of the two rocks within a chain of each other, but the absolute junction was obscured, it taking place in a gully, and unless a trench were cut across it could not be seen. It certainly looks very decisive on paper, but there are other sections as decisive on the other side of the question, and, unfortunately, none are of such clearness as to set the matter at rest.

D—D is only a variation of B—B, while the section A—A (from Black Point to Cement Town) represents the cherts of the fossiliferous series, as coming from under the auriferous series, which I cannot help thinking is correct.

Again, as far as seen, the Rainy Creek section represents the auriferous sandstones as overlying conformably the madrepore limestone and cherts; while, although the junction is not seen, the section at Garvy's Creek clearly points to a positive unconformity, and I cannot reconcile myself to the idea that the cherts of the fossiliferous beds are the equivalent of the auriferous sandstones.

10th January, 1874.

Up Murray Creek to Cement Town. Followed up its main branch to the saddle on which it rises, and descended into the so-called left-hand branch of the Inangahua, for the purpose of examining the fossiliferous beds where they crossed the river in their northerly strike. Found the auriferous rocks in the upper part of Murray Creek standing to the east of the straight line in the strike of the vertical cherts and quartz slates at the township, which might imply that the auriferous overlaid the fossiliferous beds, but the coal formation prevented my making matters any clearer here. Reaching the river bed of the left-hand branch, just where a survey line runs down to the river, found the black limestone that overlies the madrepore limestone full of shells showing beautiful sections on the weathered surface, but no fossils were discernible where the rock was broken. Then succeeded the great madrepore limestone, dipping E., exposed in great thickness not less than a mile, and making two anticlinal ridges. The southern side of this last ridge was succeeded by cherts, and here, for half a mile, the section was lost. Then, up the river, appeared the auriferous sandstones and silky slates dipping W., though at a very high angle. Another three-quarters of a mile brought a complete change of rock, in the shape of a conglomerate composed of angular masses of granite and auriferous sandstone, many of the granite boulders of great size, five to six feet in diameter, and in some cases more, and looking as though just broken from the parent mass. The sandstones were generally in smaller pieces, but equally angular in shape. The whole at once reminded me of the Ten-Mile North Beach, Greymouth, and also suggested the possibility of their having something to do with the conglomerate described by you as occurring in the gorge of the Buller River. They are of great thickness, more than a mile of exposure, at an angle of 50°, though this becomes less near their upper part, where the conglomerate is succeeded by sandstone with plant remains, and, at a little distance, by a seam of coal, of which I could not ascertain the thickness, but it seemed to be of good quality. All these beds from the base of the conglomerate were dipping up the river, or to the E., and at less than a quarter of a mile from the coal the coarse reddish granite made its appearance in the bed of the river, with the coal seams running down on it sharply unconformable. A little distance further brought me to a fine-grained syenitic-looking rock, of which you see much in the Inangahua river bed. But time did not permit of my going any higher up the river, and I did not consider I had any business beyond the granite. At this point, on both sides of the river, rose high mountain masses with vertical cliffs of the coal rocks, apparently the upper beds, and probably containing fossils similar to those got at the Ten-Mile, some of which I got in Rainy Creek, and mentioned in a former letter. On the range to the south-west of the river (the left branch of the diggers) the coal seems to dip to the S.W., and must thus form a syncline; and on the north-east side of the river the dip is south-easterly, and is continuous in that direction till the beds come in contact with the granite. The auriferous rock on the north side of the left-hand branch seems confined to a narrow belt, and may not again make its appearance to the north.

I enclose a rough section of the rock seen in the left-hand branch (right hand) of the Inangahua.

REEFTON, 13th January, 1874.

I learn that—according to Mr. Caples—the two divisions of the auriferous rocks meet in Boatman's Creek, and that the fossiliferous beds do not reach so far, but in what manner they disappear he is unable to say. If they underlie the auriferous a section should be seen; where the auriferous rocks mantle round their northern extremity the said section ought to show a marked unconformity. If they overlie, unconformity ought to be equally apparent, and I conceive that this cross section is of consequence if it can be seen. In one of the branches of Boatman's is found brown coal and pieces of pebbly conglomerate, so that it will be needful to see to this. I am myself also very anxious to be able to come to some determination with respect to the relative age of the auriferous and fossiliferous rocks, and this, from all accounts, will be my last chance. Again, I am anxious not to lose sight of the great conglomerate described in my last, and to ascertain how far it is conformable with the upper coal series, and where is the position of the pebbly conglomerate, for, as far as seen, it does not belong to the lower part of the formation. With this I also send you a drawing of the long-winged *Spirifer* described in a former letter, and may say that *Orthis grandis* of Lyall's "Student's Elements" undoubtedly also occurs in these beds. I think there is little doubt the collection also contains the abdominal portion of a Trilobite.

INANGAHUA CROSSING, 19th January, 1874.

Saw nothing between Painkiller and Boatman's till near Painkiller Creek, where, on the surface, lay great masses of the rough grit that overlies the coal, standing vertical in many cases, and thereby leading to the belief that the coal seam here must be very much disturbed, perhaps burnt out. These grits cap the fern hills at Painkiller Creek, while in the gullies the auriferous rock is exposed. On the way to Boatman's the coarse grit overlies the coal at several points along the track, thus implying that the coal itself rises to some considerable height along the ranges between the north branch of the Inangahua and Boatman's, and I hear of the occurrence of coal in several gullies along the line. Along the track there is no sign of the fossiliferous rocks, though I hear that in a gully that joins the Inangahua some distance above the crossing near Painkiller there are many loose blocks and boulders having fossils.

At Boatman's the sandstones seem to predominate over the slates to a greater extent than in Murray Creek. No traces of fossils.

Next day, following up the creek, found the auriferous rocks exposed in section for a distance of nearly three miles. Then the creek runs through flat country, the bed rock of which is probably auriferous, as most of the boulders in the creek other than granite belong to that series. Occasional pieces of conglomerate are seen—pieces of sandstone and shale of the coal series, and even small pieces of coal—implying that all of these are to be found further up the creek.

About a distance of two and a-half miles from the auriferous range —the interval being the flat country mentioned—the creek passes through another range, forming here a deep gorge, and exposing the great brecciated conglomerates of the north branch of the Inangahua, having the granite boulders this time of great size, some of them not less than 10 and 12 inches in diameter. Many of these granites were rounded or sub-angular, and very many looked as if just turned out of a quarry. Sandstone and slate of the auriferous series, and occasional fragments of red quartzite, but no trace of the fossiliferous rocks proper, could I see. I noticed the same fact in the north branch of the Inangahua, and that here, as there, the small pieces were perfectly angular, not one rounded pebble amongst them. This observation applies only to the lower part of the conglomerate, as near its upper part it is more waterworn, the pebbles of less size and interstratified with beds of sandstone.

I did not go further than three-quarters of a mile through this conglomerate, as I hoped to pick it up again at Garvy's. I hear much talk of a belt of granite passing through in the vicinity of this granite conglomerate, and cannot help thinking that it has been mistaken for such. Though I kept careful watch at the junction of all the little creeks coming from the south, I could not pick up the slightest indication of the fossiliferous rocks, so that I must conclude they do not pass the watershed dividing this from the north branch of the Inangahua.

There is little doubt that the convergence of the east and west auriferous rocks to a point (probably obscured by the superincumbent coal beds) a little to the south of Rainy Creek is the point of the first emergence of the fossiliferous under the auriferous rocks. This is assuming at once that the fossiliferous are the older series. The first section where they are clearly seen is one already sent—marked Rainy Creek—where the fossiliferous are to the east, overlaid apparently conformably by the auriferous, the latter forming a syncline, and probably having on their eastern boundary the granite conglomerate, as in the north branch of the Inangahua. The passage of the great conglomerate through here is not a mere assumption on my part, as persons prospecting there speak of one granite belt, then a narrow band of slate, then beyond that granite in great mass. I cannot help thinking that they thus confound the granite conglomerate of the coal series with their first granite belt. To the west, in this Rainy Creek section, the junction with the auriferous rocks are dipping to the west, in a manner conformable, and overlying, as was the east division of the section. This section, then, points strongly to an anticlinal ridge, the denudation of which has thrown the auriferous rocks into two wings and exposed the underlying fossiliferous rocks. The entanglement of the coal in the deep synclinal trough must be attributed to after movements, as shown by the horizontal portion of the coal beds lying on the denuded surface of the older rocks. The evidence here is very conclusive, but contradictory evidence is forthcoming.

A section taken from the Wealth of Nations battery to a point fully a mile beyond the point where auriferous beds first appear, comprises, in its central part, the fossiliferous beds making an unequal syncline, the eastern side being elevated in the high mountain mass, forming the sources of Coal Creek, Lanky's Gully, and Garvy's Creek (or a branch). The trough, or bottom of the syncline, may be traced from a short distance north of the Black Rocks, through Lanky's Gully, disappearing under the open which forms the watershed between that and Murray Creek at Cement Town. This section (from the Wealth of Nations to Garvy's Creek) shows the auriferous rocks passing under the trough of the syncline, apparently conformably, and leading to the belief that they (the auriferous rocks) must be the equivalents of the cherts and quartzite lying to the east of the fossiliferous belt. This was shown very conclusively as far as an instance will prove, as seen in section further up the creek. I could never get at the junction of the eastern auriferous rocks with the cherts east of the fossiliferous belt, but it seemed to me that at the contact there must be marked unconformity between them. I have, therefore, shown them in section as such.

I may further remark that there is little difficulty in identifying the slates and associated sandstones of Garvy's Creek with fossils (as I shall call the disc-like impressions there found) and the gritty sandstones at the point below Wealth of Nations, and slates of like character also having fossil markings of the same character, so that little doubt need be entertained that these two beds were once connected.

We found little difficulty in disposing of the Rainy Creek section to my satisfaction. This one, however, presents complications which I fear are beyond me to satisfactorily explain. I traced the section first from the madrepore limestone downwards to the N.W., till I lost it in the underlying cherts. Next, running the auriferous rocks upwards, I traced them till within a few yards of the cherts of the fossiliferous series, under which they seemed to pass conformably; but it must be remembered the absolute junction was not seen, though I traced the auriferous at a point close by, till their strike would have carried them close by the last of the cherts seen, and, both rocks standing at a high angle to the E., it is difficult to see how, in such case, they could be unconformable, or how it could be otherwise than that the auriferous was the underlying rock. I have no theory of explanation with anything, and must leave this section as it is.

In another section found in the upper part of Murray Creek we find the cherts, and of them a very distinguishable bed, coming from under the auriferous rocks. These cherts seem here to form the centre of a denuded anticline, dipping at first at a high angle to the W., gradually attaining to the vertical, and eventually dipping to the E. This is in precise agreement with what might be expected from evidence supplied by the last section, namely, that the cherts spoken of on the west side of the syncline are only hidden by the auriferous rocks, and the dark brown bed which is exposed in the tail-race, Cement Town, can be easily recognised some distance below the madrepore on the east side of the syncline, so that there is no doubt about the cherts really underlying the auriferous rock in Lanky's Gully, but that they have been brought into such a position as to show the auriferous rocks apparently underlying.

In following up Murray Creek past the Westland coal mine and crushing mill we find auriferous rocks considerably to the east of the strike of the cherts at the junction of Coal Creek, which is another presumed proof of their superior position, as, at the high vertical angle at which the cherts stand, they, if any rock did, should have made their appearance here. Here the coal beds again cover the junction, and nothing further is seen till the north branch of the Inangahua is reached, where, to my mind, the section is conclusive enough.

In the centre is a double anticlinal, composed entirely of the limestones of the fossiliferous series, flanked on the east and west by auriferous rocks, the western side being being partly conformable. The eastern side shows the auriferous rocks dipping to the west, and apparently coming in contact unconformably with cherts that overlie the madrepore limestone on its eastern side. The coal beds, in like manner, appear on either flank, as though the whole had been lifted in one huge anticline, and the present position of the several rocks brought about by denudation.

In the section of the north bank of the north branch of the Inangahua, sent you in my last, you require to add both the auriferous rocks and the coal beds, both dipping, as far as I know, northerly, and the section will then be complete.

With respect to its continuation northwards, and the ultimate disappearance of the limestone, I think that it is too deeply seated in the base of the mountain to admit of its overlying the auriferous rocks, and not reach further to the north than one or two miles; and I think I have shown that it cannot reach further, seeing that no creek falling into Boatman's brings with it any fossiliferous rock, believing, as I do, that the auriferous rocks flank round and bury up the fossiliferous.

I returned from following the section in the upper part of Boatman's Creek, believing that I would again pick it up in Larry's, and thence trace the brecciated conglomerates to the Buller Gorge, but I was disappointed. As by a rough sketch map of the reef, one of its branches is made to pass round the head of Boatman's Creek and drain a watershed with the North Inangahua, I thought in going up the creek to the reefs to have seen something of the coal beds, but the whole of the low country and low spurs of the ranges are so smothered in drift that nothing of the coal rocks is to be seen, though I hear that there are coal seams in Italian Gully and also in the next creek to Larry's, there forming the bottom upon which the gold was found.

The rocks in the creek at the Caledonian mine do not differ so much as I was led to expect in your instructions. They are still an alternation of silky slates and sandstones, but darker in colour than either at Boatman's or Murray Creek. Much stone in the creek bed bore yet a closer resemblance, so that I came to the conclusion after all that these are only a modification of the same rock found in other parts of the field. The sandstones are more micaceous, and never have the ferruginous appearance of much of the Murray Creek sandstones. But the slates have the silky feel, though darker in colour also.

On the 17th left the reefs, and in about one and a-quarter miles came upon the granite *in sitû*, with the slate and sandstone overlying at a comparatively low angle, as seen in section.

I examined the junction as well as I could, and found a quartz reef passing upwards through the granite and into the overlying sandstone. The slates here were much altered into a dark, greasy, talcose slate, and the sandstones, though less altered, to a dark, glistening, semi-crystalline rock. I need not have gone further, but I had yet hope that when the granite was passed I might find something of the coal series behind, for which purpose I pushed further up the gorge. High granite ranges rise on either side, and sometimes confines the creek within deep, impassable guts, through which the water rushes with great force.

A little more than three miles brought me through this granite. It suddenly ceases, and highly altered slates, standing at a high angle, come against it in the direction of their strike. Here the sandstones, as well as the slates, were very much changed. A quarter of a mile above, the creek divides, the larger branch going away to N.E., and the other nearly S. Half a mile further the latter again divides, the larger branch striking to the E. I followed the more southerly for about two miles, when it turned to S.W., and seemed to head for the granite range. In the creek I saw nothing but old slates or sandstones, more or less altered, and a few blocks of syenitic granite with small circular crystals, no trace of the younger rocks being seen.

I then returned to the middle branch, and observed that it brought down nothing but auriferous slates and sandstones, in character like those just described.

I returned to the main junction, and going down the creek encountered a granite dyke on its south bank, not more that six feet wide, but increasing quickly in the direction of the granite range to the north; and, on crossing the larger branch, it had increased to a width of something over three chains, the rock overlying it being much changed, and that underlying less so, like the larger mass, having a large vertical junction on its S.E. side, and less so on the N.W.

INANGAHUA CROSSING, 20th January, 1874.

The shell most plentiful on both sides of the river is a smooth *Pecten*, of considerable size, about 2½ inches in diameter and height. What we call the *Inoceramus* of the Cobden limestones is also here, and fragments of an *Inoceramus* with a vertically-fibrous shell, which I take to be undoubtedly cretaceous. A *Lima*, similar to that from the Curiosity Shop, is occasionally found. A concentrically-ringed shell, having the outline of a *Cardium*, occurs in one or two instances. The *Ostreas* and *Waldehemias* of Point Elizabeth are here, though not plentiful, and a small specimen of the large oyster I got at the Nine-Mile Bluff; also an oyster very brightly nacreous and semi-translucent, and a *Cucullœa* of a most inequilateral form, and many more.

CHRISTIE'S, 22nd January, 1874.

I found here a large *Dentalium*, not seen by me elsewhere in these beds; sometimes 4 inches long and quite ½ an inch thick at the thickest part, striated longitudinally, and, but for its more slender proportions, very like one found in the tertiary beds of the Hurunui. The large oyster is here of full size.

From yellowish brown boulders I got fossils in every way similar to those from the banded sandstones of the same colour at Greymouth, and I have got one or two very fine specimens of *Echinoderms*. Dicotyledonous leaves are also here, and a peculiar star-like fossil in the Amuri Bluff, which I could never get distinct there, came out beautifully here. Indeed, the whole of the fossils from the marls very much resemble those that immediately underlie the upper Amuri Bluff limestones.

At the Amuri Bluff you could not but remark that peculiar bed just under the limestone quarries—a fine-grained limestone band, full of small green and black angular pieces of igneous rock. This is here also, as you have doubtless observed, and with the fossils overlying, as at the Amuri, the resemblance is very striking.

At the junction is a very peculiar fossil band, which contains a very considerable variety of shells, mostly univalves of spiral form, but so enclosed with siliceous encrustation that extraction is impossible. This material will make the most beautiful of polished slabs, as the successive coating of siliceous matter in thin lines following the outlines of the shell, the lines being sometimes red, give the whole the appearance of fortification agate.

The marly beds and sandstones underlying at Christie's strike N.E. and S.W. 80°, and run down the river almost to the junction. At the junction, however, I found the fossiliferous bed and underlying grit striking N.E. and S.W. 20°, the dip in each case being to the S.E. The deflection of strike, I am convinced, is very sudden.

I have come to the conclusion that the old rocks at the junction are the auriferous rocks of Murray Creek. The slates and tufaceous sandstones are, I think, the same.

OLD DIGGINGS, BULLER GORGE, 25th January, 1874.

Travelled from Christie's by way of the pack track along the foot of the limestone range. Occasional masses of the more crystalline limestone were strewn along the track the whole of the way, showing their position here to be in the same horizon as at the landing on the Inangahua. Black or dark-coloured marls are everywhere the bed rock—at least in all accessible places. I did not get bearings, but the whole seemed to dip to the S.E., that is along the range that terminates in the White Bluff, about two miles below the junction. At Coal Creek the dark shales abut against the old rocks where the track crosses the creek.

Across the river noticed that the breccia was at first fine-grained, then, opposite the high peak of the hill behind Grainger's Creek, very coarse, having in it great masses of auriferous slate (silky slates of Reefton series). Further down the matrix became more sandy, and just opposite an old clearing the beds became distinctly stratified, the stratification higher up the gorge being extremely doubtful. Sandstones and black shales full of vegetable remains suddenly succeed the breccias; then thick beds of white and light-grey fireclay followed black, hard, siliceous, fine-grained, and flaggy beds (weathering red sometimes), which continue interbedded with the black crumbling shales till the first pebble beds are met, opposite and a little above the mouth of the creek that falls in just above the accommodation house.

I succeeded in getting from a thin bed of sandstone close to the breccias a few specimens of ferns rather indistinct—the long, slender

Tæniopteris, and much of the grass-like threads (many of them branching into three or four). *Pecopteris* is also present, but very scarce, and another that I have not seen anywhere else. It is not a mere accident, as there are two of them on the same slab, and on another and distinct slab the same thing may be traced. I regard them as the flowers of the grasses I speak of above. The bed in which distinct plants are to be found is not above half an inch thick.

On the 25th went to see the coal seam in Coal Creek. Could not see the underlying rock, nor see the thickness of the seam. It seemed, however, to be very considerable, about eight feet being exposed in the bank, and, to all appearance, it was of much greater thickness. Two chains further down the creek, coal is again seen in the bank, and, as what lies between cannot be seen, I cannot say whether this is the lower part of the same or another seam. This last appearance of coal is underlaid by a coarse, gritty fireclay. I found the sandstones, slates, and other stratified beds overlying the breccia to strike, in their lower part, due E. and W., and dip S. at 45° to 50°, which continues the same till the first pebble beds are reached. Just before the change takes place the strike is W.N.W. 70°, dip 50° W. The red sandstones overlying strike W.N.W. 55°, dip 45°. I found in Coal Creek the coal and sandstone overlying to strike N.E. 50°, and dip 10°. You will thus see that there is radical unconformity between the brown sandstones which strike up the creek near Hughes's, to make a junction with the coal seams about one mile from the river.

Following these beds down the river they lose their pebbly character, and, about half-way between Hughes's and the point round which the fluming passes, are full of angular pieces of rock. This rock is exposed on both sides of the river just above the rapid below Hughes's. Their colour and character are the same, and there is no doubt that the red sandstones on the north side of the river opposite Hughes's (those now spoken of), with their accompanying pebble beds, are interstratified with the underlying slates. Their connection on the south side of the river is clear enough with the coarse sandstone of the hill above Lovel's Point (round which the fluming passes), and as at several points on the track over Lovel's Point the beds strike W.N.W. 70°, dip 35°.

Leaving Hughes's I noticed that the coarse, brown, pebbly sandstone yet continues as far as the middle of the rise that leads over Lovel's Point, the sandstone here being full of plant remains. On the far top of the hill the strike is the same, the dip somewhat higher, and the rock coarse sandstone with pebbly beds, red or grey. These beds lie at no great distance above the slates, and are thus in the position of the red sandstone and pebbly beds opposite Hughes's.

A very good section of the point is to be got as you pass down the river, or on the opposite bank, and I observed some alteration in the angle of the dip, it being higher close to the point of junction with the slates. I can hardly regard this as an unconformity, more especially after showing that this same sandstone connects itself higher up the river with the brown sandstone and pebble beds that are admittedly a part of the red shale formation. If I could admit of an unconformity here it would be of great value, as defining the range of dicotyledonous plants. This horizon would unquestionably form their lower boundary.

South of the point where Coal Creek leaves the limestone range, the limestones that form a high, bluff hill to the east of the creek coming in at Hughes's dip at a much higher angle than do other parts of the limestone, and there I should suspect the coal rocks to be in the vicinity.

On the 26th passed over the point, and followed the track as far as Blackwater. Where the road reaches the comparatively level ground we find the thin bedded sandstones and cherts here, as on the point, overlaid by the pebble beds, which continue nearly coincident with their strike, so that you may trace the same beds for a considerable distance, till you come to Blackwater, going up which a little way shows the beds of sandstone and pebbly beds underlying.

Bearings taken between Lovel's Point and Blackwater show the beds striking W.N.W. 50°, dip 15°; and near Blackwater W.N.W. 65°, dip 20°. Crossing the Blackwater, nothing is to be seen save the coarse, pebbly, sandstone boulders coming from the range above till Blackwater Rapid is reached; opposite that, in the road cutting, the thin-bedded, fine-grained shales are found, S.E. 50°, dip 12°, the dip having now changed to the east. I could not fail to observe the junction of the shales with the coarse beds overlying in the long reach below the rapid, and there the appearance of unconformity is strong enough. But here, of course, I could not cross the river, and had to content myself with what I could see on the south side of it. I found as I neared the axis of elevation, which on this side is considerably further down, that the beds were striking the same, but dipping as high as 40°, which, two or three chains further on, became vertical, and changed from the shaly beds to the pebbly grits. These last here seemed to underlie the shaly beds, and, as I saw here no breccias, I concluded that these pebbly beds must be their representatives. The shaly beds are again seen eight or ten chains further down the road, striking W.N.W. 55°, dip 82°. Beyond this, between this place and Hawke's Crag, are well-washed pebble beds with plant remains, and these are followed by the great breccia, which, at Hawke's Crag, is mostly composed of a dark-coloured sandstone; but a mile further on shows a mixture of that with mica schist and granite, after which a nearly pure granite conglomerate succeeds, resembling the conglomerate of the North Inangahua and Boatman's. This seems to form the upper bed, as on the western side of this great conglomerated breccia, mica-schist breccia, and eventually mica-schist, succeed in downward succession. I followed these beds along as far as the Little Ohika.

The chief question in connection with these lower brown sandstones and conglomerate beds is their relationship to the upper coal and the overlying marly and calcareous beds. I much incline to the belief that there is unconformity between them, a conclusion which is not to be avoided —*i.e.*, if the brown sandstones on either side of the river at Hughes's are the same, and I cannot see wherein they differ—and if unconformity exists between these sandstones and the slates at any point it ought to be seen at Hughes's.

If there is unconformity between these red sandstones and the upper conglomerates it ought to show strongly just before reaching Hawke's Crag, where the upper beds would cross through from Blackwater, there making a most marked unconformity. If so, I failed to see it, and yet I noticed on the western wing of the anticlinal, pebbly beds and coarse sandstone, next shales; then well-rounded conglomerate, next dark-coloured sandstones with plant remains, next the breccias of Hawke's Crag—all more or less conformable.

I got from Coal Creek seam, in the overlying sandstone, three varieties of leaves; and the coal, after being overlaid by about three feet of quartzose sandstone, is followed by an intensely black-grey shale that, I believe, has much mineral oil in its composition. This is followed by dark shales having much mica, otherwise very like the former. These have concretionary elliptic masses, very hard, and in every way resembling the Saurian boulders of the East Coast, but I could see nothing in them. The black shale forms a flat of some width, behind which rises the limestone range.

WESTPORT, 29th January, 1874.

In the Buller Gorge, just before the river debouches on the plain, the granite becomes gneissoid, distinctly stratified, and sometimes interbedded with mica schist. This structure becomes very apparent on crossing the ferry at the mouth of the gorge, where highly-contorted gneiss is exposed in the road cutting on the north bank of the river.

In travelling along the road my attention was attracted by much of the dark, bituminous, micaceous shale amongst the shingle used in the formation of the road. These pieces of shale are full of plant remains, and I succeeded in getting distinct dicotyledonous leaves from some of them. This leads to the inference that the lower coal is exposed along the flank of the granite range on the north bank of the Buller, and I have little doubt that the spurs that run down in the direction of Westport contain the upper coal at least.

The only rock exposed *in sitû* was a fine bluish sand or sandy clay, in which I could find no trace of fossil remains save worm borings filled with white sand.

HALF-WAY HOUSE, CHARLESTON ROAD,
1st February, 1874.

On 31st January left Westport for Cape Foulwind, and, on reaching the point where the coach track leaves the beach, found the same sands I mentioned as occurring on the road between Westport and the Nine-Mile (Buller Gorge). They here contained the sandworm borings, and some shells contained concretionary elliptic masses of seemingly the same material, which, however, did not seem to contain fossils. These beds are here distinctly stratified in thick masses, and in parallel lines to the stratification have frequently small nodular concretions containing fossils occasionally. From one of these nodules I got a shell which I have never before seen, *Nummulites*, and many of the small microscopic forms common to the black marls under the Cobden limestones, are in these beds. But that is not enough to prove they are identical. The limestone here is, without doubt, the same as that which crosses the Inangahua at the Buller junction, and the sandy beds are, without doubt, the equivalent of the blue marly beds exposed in the Inangahua at and above Christie's, as far as the vicinity of the landing. These blue sands at Cape Foulwind are striking S.E., and dip to the N.E., and are distinctly unconformably overlaid by a bed of shingle containing gneiss boulders, whence is probably derived a field of such boulders exposed at low water on the beach. This boulder bed seems to be very thin in places, if not absent, and is, where present, overlaid by a bed of peaty lignite about eighteen inches thick, of very recent appearance, but covered by a thick bed of ferruginous sands, and having acquired the consistency almost of a rock of its class of secondary age. These sands cover the blue beds till they are succeeded by the limestones, which, scarcely half-way from Cape Foulwind to the Half-way House, appear on the beach lying directly on the gneiss, and having gneiss both to the north and south of it. This limestone has the same curious structure as that which crosses the Inangahua at the junction of that river with the Buller. I got in it a fragment of the large oyster, but otherwise distinct fossils are very scarce.

Where the beach again becomes rockbound (one and a half miles north of Charleston) found the rock on the beach to be gneiss, finer in the grain and having none of the felspar crystals, as at the Half-way House, but veins of crystallized felspar two to six, or even eighteen, inches thick. The gneiss is very distinctly stratified, but dips in the contrary direction to that at the Half-way House. At the point where the gneiss first appears the grits of the coal measures first appear also, fine grained, and exposed in the road cutting that leads on to the beach at the Racecourse Hill.

Passing through Charleston, found the country between there and the river (four miles south) to consist of little hills and knobs of gneiss, having between them brown sandstone and beds of brown coal. The gneiss crops through these beds close up to the limestone range on the south side of the river, four miles south of Charleston. The whole country has the same character till you come within a mile and a half of Brighton. That is, the brown coal has been deposited on a denuded surface of gneiss, which in turn is likewise denuded, and is, in consequence, found in all imaginable places, sometimes capping these little hills of the underlying rock, sometimes as a patch resting against its side, and not unfrequently filling the hollow between two ridges of gneiss.

From Charleston to the river (four miles south) the limestone tends to keep rather inland from the coast, but from the south it again approaches the coast, and reaches the sea a little south of Fox River.

At Brighton it certainly stands further inland than one and a-half miles further north, but that, I think, is less due to alteration of the strike than to the configuration of the country.

BRIGHTON, 3rd February, 1874.

There is great similarity between the granite breccia exposed behind the township and the upper granitic portion of the Hawke's Crag breccias. By reference to my letter which treats of the Hawke's Crag breccias, you may remark that some portion of these granite breccias (Hawke's Crag, upper part) contain sandstone beds with small quantities of coaly matter. An exact parallel is to be found here. It is from such beds of finer material that I have been able to make out the strike and dip of these breccias in both localities.

Returning to the vicinity of the cemetery, where there is a coal mine, I went to examine it, for I could not conceive how coal could be there unless interbedded with the breccias, the latter seeming to surround it on all sides, save to the north-east. I found the coal overlying the granite breccia, not interbedded, and decidedly unconformable—the underlying rock striking, at the burying ground, immediately under the coal, S.E. 25°, dipping N.E. 35°, whilst the overlying coal seams at the point marked are nearly horizontal, but, just behind the township, strike S.W. 45°, with a dip of 7°. The coal is underlaid by fine quartzose grit, and overlaid by the same material, succeeded by greasy micaceous shales very like those of Coal Creek, Sawyer's Point, but without the concretionary masses there seen. Leaves and shells are here associated in these shales, and I got a small *Natica* from them as well preserved as though buried but yesterday. Immediately north of the township the breccias run out to sea, and are not again seen, the gneiss rock taking their place. At St. Kilda, one and a-half miles north of Brighton, the coals and their associated rocks occupy the intervening space, except in one particular place, where a mass of conglomerate seemingly shoots up through the coal into the overlying coal beds. I employed the afternoon in collecting from these marls, and the collection, as far as made, leaves no doubt of the identity of these beds with the Ten-Mile and Nine-Mile Bluffs of the Brunner coal field.

Over the ferry there is a great variety of shells, chiefly *Pectens* and sea urchins. In the dark marls overlying the coal the large oyster is plentiful, and, this time, in the soft marly rock.

There is not the slightest doubt remaining that the underlying breccias are unconformable—though the coal series is fully represented—between the Fox River and the Penguin Rock, but the ground is so disturbed by slips that the section in its lower part cannot clearly be made out.

From what I picked up, the overlying sandy beds found at Cape Foulwind and at the mouth of the Buller Gorge overlie the limestones, and, in a particular locality, contain abundance of fossils. The granite described as being found at the junction of the two branches of the Fox River is doubtless the gneiss of the coast between Brighton and Charleston.

6th February, 1874.

Went up the Fox River to its source in the granite range.

The granite breccias continue up the river almost to the limestone on the north side of it, rising to some height above the river bed, dipping E. at an angle of about 45°; while close to the water's edge is exposed a coal seam—brown coal, having dark-coloured sands below and grey quartz sands above, succeeded apparently by dark micaceous marls.

The limestone in the gorge is of enormous thickness, 500 feet at least, of pure calcareous sands, partaking more of the character of the Tokomairiro limestones than any other of the same age that I have seen. The lower portion is white and compact; the middle flaggy, sometimes very finely, not more than two inches in one particular horizon between the bedding planes, and this characterizing twenty or thirty feet of rock. This part of the bed weathers red. The upper part is more compact, and of a white colour. The limestone is dipping to the N.E. at an angle of 10°, but near the coast line it must dip at an angle considerably greater, for the lower part of the limestone being at a considerable height behind St. Kilda reaches the level of the river bed a little more than two miles from its mouth, where, as above mentioned, it dips E. at about 10°.

Fossils, it would seem, as far as shells of any size are concerned, are scarce, but the limestone on weathering shows to be nothing but a mass of corals and fragmental shells.

Followed the right branch, and found the limestone cliffs scarcely to diminish in height, and the watercourse to be shut in by a very narrow gorge. A mile brought me through, but still the limestone continued in high bluffs.

For the next one and a half miles I failed to see the rock in the creek bed, but the high continuous bluffs along the range on the south bank left no doubt as to its presence. When rock was next seen, it was highly calcareous marl, but could scarcely be called limestone. It has, however, the same strike and dip as the underlying limestone, and hence I concluded that it conformably overlaid the limestone. This rock, when rising into high bluffs, usually overhung from the dry face, crumbling away more readily than the moist upper part. No fossils were to be seen in it save a small *Dentalium*, which does not seem to be confined to any particular bed. Some distance further up the river, blue marls in conformable sequence appear, highly fossiliferous, and contain a great variety of tertiary shells.

This formation continued to, and even formed, the outer end of some of the spurs coming from the high range, and abutted unconformably against the older rocks there exposed.

Some miles down the river I observed indications of the coal series in the shingle of the river bed, sandstones with plant remains, and fine-grained conglomerates. Conglomerates became frequent as boulder masses in the creek, and shortly rock on the flanks of the higher ranges made its appearance, first as sandstones and intensely black shales, also coaly shales. These rocks were dipping E., and, further up the creek, W., thus forming a syncline, the lower beds of which were pebbly conglomerates, and eventually coarse granitic breccias similar to those exposed at the mouth of the Fox River.

The crystalline rocks here are chiefly felspar and micaceous gneiss, which fill the creek bed with boulders of great size.

In returning observed that the tops of the granite ranges to the south seemed covered with horizontal strata, which I concluded to be coal beds, and as these beds seemed to dip to the E., they doubtless make a junction with the breccias of the Buller Gorge, in the manner indicated in the plans.

I saw no granite, but have been told that it exists in the left branch, in a soft crumbling reef rock.

I have been assured that a seam of coal, six feet thick, is to be found about one and a-half miles to the west of the lower spurs of the granite range, and consequently on the west side of the syncline. It is said to be bituminous, like Grey coal. I got in the coal sandstone traces of dicotyledonous leaves, and hence have not hesitated to connect this belt of coal strata with the micaceous shales bearing such leaves at the Buller Gorge.

7th February, 1874.

You will see that the Penguin Rock, the point opposite, and a narrow strip on the coast further to the south, and the point beyond the granite, all belong to the west side of the axis of upheaval, and, save in the last instance, are not connected with the main body of the limestone.

The limestones are full of concretions of black flint, and the only thing of interest was the occurrence of a few fish vertebræ. Got reptile (tortoise ?) bones, etc.

Dark micaceous marls overlie, in Woodpecker Bay, the Island sandstone, and these are full of that peculiar shell I have mentioned as so characteristic of the black marls of the Omotumoto—a species of *Turritella.*

Yellow sandy clays succeed, and then some thickness of loose white sands, which are again followed by black clay marls with soft concretionary boulders often containing shells, amongst others *Fusus* and the *Dosinia* of the Waipara. From these marls, also, I got a crab, body and legs entire.

11th February, 1874.

Three miles south of Charleston. From this point I could see that up the Nile River the limestone must reach almost to the granite range, and consequently must leave, if any, only very narrow belts of tertiary strata and older coal-bearing rocks. The direction of the north end of the limestone range would bring it to the coast somewhere near Cape Foulwind.

Looking south, and inland, I could distinctly see the difference in the outlines of the granite portions of the range from that composed of carbonaceous strata, and that the latter commences as a low range some distance north of the right branch of the Fox River, gradually encroaches on the higher range, and eventually shuts off the granite to the east, taking possession of the higher peaks of the front range a short way south of the left branch of the Fox River.

If the limestones at Cape Foulwind belong to the Island sandstone division, the sandy marls lying above them underlie the Cobden limestone.

Up the Mokihinui I found granite on both sides, from about three-quarters of a mile from the mouth till about one and a quarter miles; the space between the granite and the sea being, I suppose, another rock. Beyond this, at the first turn in the river, the lower coal marls begin, and are distinguished from those to be mentioned afterwards by being interbedded with sandstones and fine-grained conglomerates, the shales themselves having strings of nodules that may be a calcareous carbonate of iron.

These shales strike S.W. and dip at a high angle, and are exposed over no great depth of section, their exposure being chiefly along the strike of the beds, and not seen over forty or fifty yards, unless some shales seen further up the river, between the main range and the coal sandstone, belong to this set of beds.

These shales remind me strongly of the black shales with similar concretions and sandstones between Nugget Point and Cannibal Bay.

Further up the river, at Page's Creek, is the coal sandstone, with three distinct seams of coal, one averaging fully six feet, and exposed on both sides of the river. Beyond this the river cuts through the sandstone formation, and marls overlying the sandstone appear. I conclude they are the black marls of the Omotumoto.

I should think, from the little *Pecten* with ribs not reaching the margin of shell, that they overlie these sandstones, but cannot say.

Up Page's Creek nothing but sandstone and the shales in immediate connection with the coal could be seen.

Crossed the river, and, going along the coast to the north, found the first point to be white marly beds of fine grain and clear stratification, but strangely associated with beds of granitic breccia.

At the point spoken of these marls are well exposed, and to the south seem to flank the granite range as far, at least, as the Mokihinui River. To the north they seem to form a syncline, having for their eastern base a coarse granite breccia, which, as I said, was strangely intermingled with the upper part of the western side of the syncline, but here, on the eastern side, is developed in considerable thickness at their base. These beds strike N. and S., and north of the first point north of the Mokihinui form a deep and narrow syncline; the whole formation, except at the point and south of it, being submerged at high tides. The white marl is somewhat uncertain in the strike, though its general direction is clear enough, but sometimes it will vary considerably, and, in one instance, so much as to turn sharply round at right angles.

These rocks at last strike off to sea about five miles north of the Mokihinui, and for the next two miles the coast is bounded by granite, and thus the white marls in the back are prevented from showing on the coast. But in a creek, as far as I went, I detected their presence, and have no doubt that they occupy the valley beyond the high coast ranges.

I observed on the coast, associated with the granite, red quartzites, but no red slates, either here or up the Mokihinui; but in a creek one mile north of the white point the best section of this country is likely to be got, coming, as it does, from the high mountain range, and intersecting, as it ought, the different sections in turn.

At White point I got a curious oyster, corals, fish spines of Nine-Mile Bluff, and so I expect to see these white marls pass under the dark marls of Omotumoto.

Went up a creek that falls into the river half a mile above the town on the south side.. About one and a-quarter miles from its mouth first saw the rock in the creek bed : a blue micaceous sandy marl, sometimes with bands of sandstone, coarse and pebbly, sometimes having concretions. Some distance up the creek, fossils occur in these concretions and sandstone beds, which have a decided tertiary look. They stand at a high angle (from 60° to vertical), and yet pass strata which I know have coal beds in their close vicinity in such a position that it is difficult to see how they can do otherwise than underlie the tertiary beds. The fossils found in these beds have a close resemblance to those overlying the limestone up the Fox River.

Such would be the only explanation of the beds as seen in this creek, as near the top of the hill coal is found, and much coarse sandstone is seen in the creek just at its source.

Went to the creek that runs back to the high range and reaches the coast north of the white point. Observed in the creek boulders of the white stone I saw along the beach. I found, first, granite on the coast, forming a range fully a mile in width, after which came the white marl stones, followed by beds of coarse sandstone and angular conglomerates imbedded in the white marly matrix; then beds of finer grain, and having the fossils of the sandstones that overlie the Cobden limestones—*Echinoderms*, etc.

You will from this see that these white marls must be closely related to the Cobden limestone, though there is little doubt that they are the same as the beds of like appearance on the coast.

The tertiary beds south of the river, more especially in the beds of coarser grain, have a great similarity. The identity, however, of the beds with the dark marls overlying the coal in the Mokihinui cannot be doubted. But I could not make out how they were otherwise related, as, in following them up in the creek bed, they disappeared under the surface accumulations of an alluvial flat.

I hear that old slates full of shell impressions are to be found in the Upper Mokihinui. These can be no other than the Reefton beds.

Hearing of the existence of red slates in the mouth of the gorge on the north side of the river, I went up in a canoe. A further look at the black marls just beyond the first granite in the mouth of the river showed that it could not be well separated from the black marls overlying the coal sandstone further up the river, and a slip showed it to be overlaid by coarse sandstone and conglomerate, with which the whole of the white marls seem to be interstratified, and always in angular blocks, a waterworn pebble bed being of rare occurrence. A mile or two beyond the coal mine I found the black marls overlying the coal sandstone to dip to the N.W. at a low angle, and observed in the river bed great masses of soft blue sandstone, which seemed to have come from the top of a low range that, on the north side of the river, runs from the coast granite range to the high inland range beyond the coal beds. The marls were full of concretions like those in the blue marly beds at Christie's, and they are exposed on the river banks as far as the lower spurs of the high range at the mouth of the gorge.

A blank of about two hundred yards intervenes, after which a blue sandstone, weathering to a rusty iron colour, shows in the north bank of the river, which shortly comes in contact with a fine-grained granite, which, I am informed, continues for some miles up the gorge. Taking a creek of some size crossing from the north, I found soft blue sandstone not unlike the sandstone from the tertiary beds, which weathers to a black red colour, and is, without doubt, the parent rock of the masses lying in the river further down. This is followed by dark-coloured marls, and then by light-coloured marls that could barely be called white. I think this sandstone and that along the inside of the coast granite are the same, and, the strike of the coal sandstone at the mine being nearly E. and W., will give the section from N. to S.

I have not been further than five or six miles along the coast to the north, but hear that the white marls again come to the coast before getting to the big hill on the track to Little Wanganui.

WELLINGTON, 25th February, 1874.

On the 21st I left the Mokihinui, and observed that the granite again comes to the coast four miles south of that river, forming a high, precipitous range to Ngakawau, where I arrived in the forenoon. Paid a visit to the coal mine, and examined the marly sandstones underlying the coal, as seen in a mine on the north side of the river, but could find nothing in them. I also visited several localities on the north side of the river where prospecting for coal had been carried on. In all cases these prospecting works showed that no workable coal existed, a narrow strip of the outcrop, denuded by the gorge of the river on its south-east side and cut out by the granite on the north-west side, being all that remains. In the principal prospecting shaft on this side of the river, where the best indications are found, the seam stands at a very high angle, and is so intermixed with elliptic masses of sandstone as to render profitable working impossible.

On the south side of the river, coarse gritty sandstones overlying the coal are succeeded by micaceous sandy marls with dicotyledonous leaves, *Echinoderms*, and a small *Leda.* It was thus evident, from their position and contents, that these marls agree so exactly in character with those overlying the coal at the Mokihinui and other localities whence I had already collected, that I did not consider it necessary to make a collection here.

In the afternoon I left Ngakawau for Waimongaroa, where, after visiting the tunnel and making a vain search for distinct plants or shells, I returned to the accommodation house. Arrived in Westport next day (the 23rd), whence I sailed for Nelson on the 24th, and arrived in Wellington on the 26th February, the whole trip occupying ninety-two days.

REPORTS RELATIVE TO COLLECTIONS OF FOSSILS MADE IN THE EAST CAPE DISTRICT, NORTH ISLAND.

BY ALEXANDER McKAY.

To the Director of the Geological Survey.

Gisborne, 13th March, 1874.

Sir,

I arrived at Poverty Bay on the 10th instant, and on the 11th, complying with your instructions, I crossed the ferry, and, passing down to the river bar, found the rocks there exposed at low water to be dipping at a high angle to the N.W., and very different in their composition from the beds containing Moa foot-prints on the west side of the river. These beds are bluish sandy marls, with traces of fossils, though, with the exception of an occasional *Nummulite*, I did not at this point succeed in finding anything in a recognizable state. The beds are clearly stratified, but considerably contorted in the direction of their strike, and are, at this point, exposed only to a very limited extent at high water. A few hundred yards along the shore a similar low, flat reef of rocks runs out to sea a considerable distance, the rock being less sandy and weathering brownish yellow where it is not daily swept by the tide. There are also clay cliffs on the land side of considerable height, which are composed of this marl, dipping as before mentioned, while the light-coloured beds seen from the town on the hill opposite overlie unconformably, dipping at a low angle to the south-east. The white sandy beds are of considerable extent and thickness, and the beds with Moa foot-prints seem to me to belong to this formation, rendering it of great interest.

I followed along the coast, getting fossils in the softer parts of the beds of the marl series, but nothing characteristic or decisive, a small shell in form similar to a *Leda*, and some *Nummulites*, being the most common forms. A *Dentalium*, very similar to that found in the Inangahua marls, on the West Coast, is found here also, but only sparingly. Further along the shore I found the beds become banded with thin beds of sandstone, which, as the strata were followed downwards, increased so as to occupy an equal volume with the marls themselves, and which here contained flint-like concretions. Beyond this a fault seems to have brought these beds to a much lower angle, if, indeed, it be not a recent and gigantic slip. After the exposure, in section, of two hundred yards of these sandstones lying at a lower angle, we suddenly find sandstones dipping in the same direction, but at an angle greater than even the beds west of the flattened faulted portion. These last beds, lying furthest east, are chiefly coarse, bluish sandstones, with beds of shale between, having *Dentalium* and *Nummulites* of two species, one of which I never before saw higher than the Cobden limestones. Following along the beach, these marls and sandstones suddenly cease, being replaced by a coarse breccia, which, with trifling exceptions, continues to within a few chains of the east head of the bay, where concretionary sandstone boulders of considerable size make their appearance, and seem to form the axis of an anticline, as the beds on the east side dip in the opposite direction.

Returning by the inland side of this coast range, I saw that the younger formations, in places only, cap the older marls, as the marls frequently show on the lower spurs on the north, or inner, side of the range. Near the Maori pa, opposite Gisborne, the younger beds are found at the base of the hills, and are even exposed in the estuary of the river.

12th March, 1874.

To-day I crossed the river, and proceeded up the left bank. At the sharp bend above the butts I saw, on the opposite bank, beds inclined at a high angle, which are, without doubt, part of the marl series. A little further up the river, at the island from which the shingle for the roads is brought, in the left branch of the river, marly beds are exposed, which belong to the same formation seen along the coast. At the island I crossed the river, getting on to the leading spur, which terminates on the right bank a quarter of a mile from Gisborne. This I followed back into the ranges, and, where seen, found it composed chiefly of the white sandstone forming the upper part of the younger formation of the coast range. At one point on this spur—the highest seen from the township—the marls make their appearance, and contain fossils, but nothing distinct. Beyond this peak is a saddle connected with a table-land of small extent, and along the face of its south-west scarp passes the belt of marl rock, here grey and calcareous, covered on this, the highest, point of the front range with a plastic silt, and overlaid by a bed of very recent-looking shingle, which seems, from the form of the stones, to be wave-worn. Still a little further back, in the ranges beyond, white rocks are seen on the face of the hill, which I have marked as marls of the older rock, but they may not be so. I proceeded west along these spurs, and reached the low ground some distance to the north-west of the town, noting the presence of the coarse and recent gravel on the spurs as I descended. On the point of a spur at the foot of this range is exposed calcareous marl containing fossils—*Dentalium* and others; this being the western termination of a long, narrow belt of these rocks. Leaving this, I found my way up the valley, crossed the outer spur, and returned this way to Gisborne.

13th March, 1874.

I crossed the river, and, taking the spur at the redoubt, followed the white sandy beds along the ranges, finding plant remains in the upper part of the beds, and in another locality, but in the same horizon, abundance of fossil shells, comprising *Ostrea*, *Mactra*, etc.; but in this upper bed few or no univalves. Abundance of univalves, however, are found in another fossiliferous band lower in the same series.

As this is a formation of some extent and interest, I shall here describe its members as far as I can from what I have seen of them. (1) Resting on the chalk marls and green sandstone, a coarse, broken breccia, mainly composed of the sandstones of the marl series, and which may be a local bed. (2) Well-washed river shingle, of large size, mixed with sand and sea shells. (3) Fine, dark grey sea sand, with many shells and plant remains (dicotyledonous leaves, etc.). (4) Estuarine silts mixed up with shells, forming a table-land, on portions of which rest (5) sandy clays with shell casts of *Mactra*, etc., covered by (6) brownish grey sands, in places cemented with oxide of iron to the consistency of a hard sandstone; this bed contains a great quantity of oyster shells and a few others. (7) Wind-blown sands of grey or brownish colour. The white sands so characteristic of this series are the beds immediately overlying the estuarine muds, and also the lower beds of the upper sandy portion of the formation. The white sandy beds vary in grain from sandy grit to fine silt capable of suspension in water.

Leaving these beds, I passed onward to the eastern head of Poverty Bay, where concretionary sandstones belonging to the *Leda* marl series, but lower in the series than any I had yet seen, make their appearance, and form an anticline. The part of the series which is hidden by younger beds on the west is clearly seen on the eastern side of the anticline, which forms bold cliffs on the coast to the north-east. I examined these rocks carefully, but failed to find any fossils in them. Fragments of a fibrous shell, which may be *Inoceramus*, are frequent in calcareous sandstone boulders on the beach west of McDonald's home station, and belong to this or an underlying formation.

19th March, 1874.

On the 14th I made a collection of sub-fossil shells, as exposed in the banks of the river within the township of Gisborne. The shells being in an excellent state of preservation, I got good specimens of all the different species contained in these beds, *Mytilus* being the only shell that seemed to have suffered, and that only to the extent, in some cases, of rendering the shell very brittle. I found that these shell beds gradually gained a higher level as their distance from the present sea beach increased, but that their thickness, though variable, clearly diminished as one followed them inland. I did not observe them more than half a mile inland from the beach, though the bed might reasonably be expected to cover all the low ground to the foot of the hills north-east of the township. I also made further examination of the fossiliferous beds of the white sand formation, making collections, but adding nothing new to the list given in my last letter. This, and an attempt to define the relations of the white sand formation with that which contains the foot-prints of the Moa, occupied me for the day, the result being that it is yet an open question whether or not the young tertiary rocks overlying the marls are the same as those containing the foot-prints.

On the 15th March, as instructed, I went to look at some coal on Mr. Bryant's property, which would appear to be associated with the formation containing the Moa footprints. I did not, however, succeed in seeing the seam, as it is covered at high water, and I was ignorant of the precise locality. I had, however, the good fortune to find the tufaceous rock with crystals of felspar frequently, in other parts of the same bed, decomposed, but here they were in their perfect state. The rock is so much the more interesting, because it contains fossils, though unfortunately somewhat indistinct. This bed underlies the highly calcareous marls, which here approach the character of a limestone. The terraces to the north-west of this point are all of the young tertiary or white sand formation. I examined them for a distance of a mile and a half, and also all the slopes of the higher hills (here freely intersected by partly-wooded gullies), but I saw no indication of carbonaceous matter that at all approached the character of a coal; after which, passing along the scarp of the exposed calcareous marls, I returned to Gisborne.

On the morning of the 16th I made preparations to start on the journey north, along the coast, and left Gisborne about midday.

On reaching the coast at McDonald's wool-shed, one cannot help remarking the beautifully-raised beach behind the present sand-hills, as level and smooth on the top as a carriage way, with its seaward slope just as the water left it. The beach at the present high water has a very different appearance, the finer material having been acted upon by the winds, which have made sand-hills. Here and there among these, and in the depressions between them and the raised beach, are relics of old Maori encampments. This raised beach continues as far as the Makarori rocks, which are comparatively horizontal, and belong to the sandstone division of the *Leda* marl series.

Northward these sandstones and shales, with occasional fragments of coaly matter between, are well exposed east of the anticline on the south face of Tauhina Point, and have a similar character as far as Tutapouri, beyond which are sand-hills and recently-elevated beds, which form the shore line as far as Turihaua Point.

17th March.—The rocks on the mainland and on Whangara Island dip to the N.W., and are green sandstone; but I was in a hurry to push on, being anxious to pass the difficult places before the rising tide should be able to interfere with my progress. I found the rocks along Stony Beach, before reaching the Old Man's Face, to dip to the N.W., and to be chiefly composed of sandstones, though marls intervene in the bay between it and the Old Man's Face, which is a sandstone bed of tufaceous character with crystals of felspar, and containing rolled fragments of white limestone. Marls succeed this till Gable End Foreland is reached, where the marls are overlaid by a white sandstone. In the cuttings of the track, which here for a few miles leaves the coast line, is the first evidence of a younger overlying formation, which, northwards, becomes the prevalent feature.

On the morning of the 18th March, on leaving Tolago Bay, I followed an inland track through some swampy country, and again reached the coast at Kopuni. Where the track crosses the next point of land, on descending the hill on the north side to Anaura, I saw fossils in the clay marls and sandstones. In a creek at Duncan's accommodation house is an abundance of fossil shells, which, however, I had only time to have a glance at, as I pushed on, and the same evening reached Tokomarua Bay.

On the 19th crossed the hill called Tawhiti, which consists of a great thickness of tertiary strata, but found on descending into Open Bay that rocks of the older series were again present in the low ground, and in the tide-way, I should think, a clear junction will be found. Along the south side of Open Bay, at the pa, where the track reaches the beach, the older rocks are exposed in the surf and in two bluffs at the mouth of the creek which falls in there. The old rocks are exposed all along Open Bay, though the young tertiaries must be close behind on the high ground. Marls with concretionary masses are exposed on the north side of Open Bay and at the pa; and yet further on the coast, as far as Whareponga, where, behind the church, an unconformable junction between the marls with concretionary masses and the younger rocks is seen. This junction follows up the north-east branch of the creek, and at the saddle seems to lead away still further to the left. Reaching Tuparoa, I there found evidence of the presence of the greensands and conglomerates, and, a little further north, the black, bituminous shales. In some of these blocks I certainly found *Inoceramus* fragments, some being loose among the matrix of the conglomerates and pebble beds.

20th March, 1874.

In the morning it rained, making the inland track very slippery, and the beach round the coal bluff being impassable for a horse, I had to find my way over the hill as best I could. Reaching Roparua in good time, and accompanied by a crowd of natives, I went to see the coal reported to be got there. I could not see in the specimens shown me the slightest evidence of a coal seam of even two or three inches in thickness, what was shown me being black shale filling the junction of two masses of rock faulted on each other. The rocks are sandstone, and look very much like the cannon-ball sandstone of the Amuri Bluff, which occupies the anticline of the Saurian beds.*

Proceeding north, I again found the light-coloured marls and the concretionary masses forming a high bluff, and, further north, the light-coloured marls covered by immense slips of mixed materials, showing no solid materials in the banks till the greensand rock is reached, passing which I reached Awanui, and received your letter of instructions.

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* See Haast's Report on the Amuri District.—Geol. Reports, 1870, p. 27.

21st March, 1874.

I examined very carefully, but without success, the concretionary masses on the beach north of Awanui, to which you directed my attention, but I did not find any Saurian or other bones enclosed in them, though I saw several dark, flinty nuclei in the masses, which, at a hasty glance, might be easily mistaken for bone. However, I was not long in finding many masses (not concretionary) full of fragments of *Inoceramus* shells.

I can find no fossils in the marls or sandstones that will in any way assist me to decide the true age of these rocks; but the compressed, tubular worm-track so characteristic of the marls in the Poverty Bay section of the beds is found here in great plenty and perfection, and there is no doubt as to the identity of the rocks in the two localities.

22nd March, 1874.

Having kept a sharp eye on the rocks south of this as far as Open Bay, and seeing no Saurian bones, the existence of which you seem to regard as probable in these rocks, I concluded therefore that what you had seen might be further north, and I went on the afternoon of the 20th along the coast as far as the saddle at Pohoutea Pa, but saw no traces of what I sought for. I noticed, however, the occurrence of the same succession of rocks that takes place at Awanui and Awatere, which would imply that several anticlinal folds exist, and that, in addition, the beds are much faulted. We thus find that for nearly twenty miles along the coast these beds are all pitched at a high angle—at least, from the north side of Open Bay to the mouth of the Waiapu River they are so—and this, at their average angle, would give an enormous thickness if not repeated.

I could find no fossils other than the worm borings already so often described, though here they are in great abundance and perfection in dark, micaceous marls, which will be described in due course.

I went next morning to the greensand rock, and in masses on the beach I got several fragments of *Inoceramus*. I went also as far as the high bluff south of the green sandstone, and, returning as the tide went out, I very carefully examined the manner of the occurrence of the greensands, and cannot arrive at any conclusion but that they belong to the beds among which they rest. In the afternoon I went as far north as the Waiapu at its mouth, thus acquainting myself with the whole north coast line as far as that river, but I found little addition of interest to my previous information, as the low range between the mouth of the Waiapu and the saddle which leads over into the Waiapu valley is nothing but grey marls, either without the concretions altogether, or having them very sparingly.

The section from the mouth of the Waiapu River to Whareponga is as follows:—(1) Grey-coloured calcareous marls, with few concretions, and these but small, the rock being dark where wet, and where dry of a light, almost a white, colour, and the cliffs, when long exposed to the influence of the atmosphere, have a light-brownish hue. This rock contains abundance of flat tubes, characteristic of the Poverty Bay beds. It is not distinctly stratified, but may be said to underlie the rock next to it in the section. There are also (2) grey sandstones much faulted and contorted, and, as shown in the sea cliff where exposed, these exhibit the most strange complications of strike and dip. They however, as a whole, strike N.W. and S.E., and dip S.W. at an angle of 50° on the average, are without fossils, and exposed for a distance of perhaps a quarter of a mile, being overlaid by micaceous shales very dark in colour, and in appearance very similar to the greasy shale which overlies the pitch coal in Coal Creek at Grainger's Point, Buller River. These shales have, in great abundance and perfection, the peculiar fossils of the Poverty Bay marls, which lie crossed on each other in layers, thus forming a complete network on the faces of the slabs when split open. This particular rock, though here in great masses, yet seems to occur as patches in the lighter-coloured marls which succeed the sandstones having large concretionary boulders in them; the boulders, as well as the containing chalk marl, have the same fossil so plentiful in the bituminous shale. In places the dark micaceous marls or shales in these beds, through the decomposition of the sulphuret of iron which they contain, deposit much sulphur on the face of the cliff as an efflorescence, and, in places where the moisture is greater, the joints of the rock are coated with the sulphate of lime. These dark, micaceous, sulphurous shales are well seen on the north side of a small creek which reaches the sea about three-quarters of a mile north of Wharariki Point. From that creek to the Awanui accommodation house, the light-coloured marls with concretions are exposed on the beach at low water, and by the bluff along the shore they gradually begin to contain boulders and water-worn rocks, and pass into a conglomerate, containing fragments of white, chalky limestone, a light-coloured, compact limestone, pieces of quartz, red chert, and coarse sandstone. This is overlaid by a bed of greensand, hard in texture and very dark in colour, without fossils, and varying from two to five feet in thickness. This is overlaid by alternations of white chalky rock with thin beds of dark greensands having rolled fragments of white chalky limestone included in them. More conglomerates and greensands succeed, and the whole may be of a thickness of 200 yards of exposure along the shore. It is then succeeded by the light-coloured marls of great thickness, which, at the point beyond, contain concretions similar to those described on the coast further north. These masses, washed out of the chalk marls, form a very rough shore at Rocky Point, where, in the cliff, highly-contorted greensands seem to rest on the marls, which at present I regard as fragments of a slip.

Between Rocky Point and Awatere these chalk marls are overlaid by thin beds of greensands, conglomerates of chalky limestone, and other rocks, and between them are irregular beds of a white chalky rock sometimes of a pale green tint, the whole being much contorted, disturbed, and overlaid at the greensand cliff by a bed of pebbly conglomerate. This bed is covered by a hard stratified greensand, which gives place to a loose greensand, passing into greensands of a harder nature, and containing great quantities of rolled fragments of white chalky limestone, the last being overlaid by a bed of pebbly conglomerates, the whole of these, together with the two beds of conglomerates, being of a thickness of about twenty-five feet. This, again, is overlaid by greensands bedded between chalk and green marls. At this point the succession is lost for the next quarter of a mile, and where next seen chalk marls only are exposed on the beach, the cliffs being entirely composed of slips. In the slips I observed the dark micaceous shale, which would seem to be here also, and bituminous shales at the point beyond Awatere, and, between that and Roporua, the chalk marls are full of concretions, and contain the fossils so abundant in these masses. The beds containing the concretions at the point are very hard and much jointed, as seen on the high bluff on the sea coast south of Awatere, and may underlie the chalk marls with the brown boulders. They are succeeded by softer and less-disturbed beds further south.

Since writing the above I have passed along the range above the slips and examined the face of the gigantic slip at Awatere Point, and found green sandstones and breccia beds, with rolled pebbles included in the base of the cliff. Above that there are contorted sandstones and indurated marls, which are exposed at the point. The chalk marls at the point are indurated and jointed so much as to destroy their stratification, but this may be made out at the slip and at a point further along. In the next bend, which is Awatere proper, the bituminous marls again appear, clearing proving that their proper place is above the white marls and under the greensands which appear on the coast nearly half a mile south of Rocky Point.

From the green sandstone corresponding to the lower beds in the Awatere Bluff I perceived small fragments of *Inoceramus* and other fossils. I have seen reasons to alter my previous view, from finding bituminous shales—described as dark micaceous shales—one mile north of Wharariki Point, also one mile south of the same point, and again yet further on, beyond Awatere Bluff. I could not do otherwise than conclude that they were the same beds, brought into their present position by the faulting or folding of the strata. The occurrence of greensand at Wharariki Point and at Greensand Cliff proves the same thing; but in two places only do the contorted sandstones of this series appear in the section—that is, firstly, further along the beach towards the saddle where the track leads over to the river, and, secondly, in the big slip at Awatere Bluff; the chalk marls with concretions between Wharariki Point and the greensand cliff not being elsewhere denuded sufficiently to bare the underlying sandstone.

23rd March, 1874.

On the 22nd I examined marls, shales, greensands, etc., on the beach for fossils, but without success, all that I could see being masses which contained fragments of *Inoceramus*. In the afternoon I passed over the coast range into a valley which led me into the valley of the Waiapu, but, as I saw little and the day was very stormy, I did not care much to push far up into the ranges.

On the 23rd I followed along the top of the coast range, descending from the highest peak into a deep gully, the sides and source of which are a huge slip. From this point I went south along the coast in the direction of Roporua, but I found the coast line between the high bluff south of the greensand rock and the point north of Roporua to consist mostly of slips, upon which the sea is at present engaged, and, except at one point, the solid rocks are not exposed. That one point, however, was of not a little interest, from the fact that it was formed of the greensand and fine-grained pebble beds, which contained the remains of fish vertebræ, teeth, scales, etc., but, as a general rule, of small size. There were also in this bed a great quantity of *Nummulites* of three distinct species, small shells of an indistinct nature, and many of the curious forms peculiar to the chalk marls, of which I procured many fine specimens. *Cidaris* plates are very frequent also, but none of the shells of them are perfect, and the spines seem in all but one case to be absent. The common forms of *Echinoderm* spines are also met with now and again; but, above all, in the matrix of the fine-grained conglomerate there were some fragments of *Inoceramus* shells, which confirms the supposed conformity of these conglomerates with those that underlie them. Going further on, till you enter Roporua Bay, the coast line is composed of materials which have slipped down from the range behind, and is therefore perfectly untrustworthy. At the point half a mile south of the greensand rock, I found on the beach a block with many fragments of *Inoceramus* in a recognizable state. I got out several specimens of *Inoceramus haasti*, so common in the Lower Amuri beds, and some small specimens nearly perfect, together with a *Cardium* and what seems to be a small *Pinna*. There can be no doubt that this block came from the cliff above. If doubt did at all exist that blocks formerly mentioned might not be *in sitû*, surely the presence of a large mass which has just fallen from the cliff, and full of large shells of a similar sort, would set the matter at rest. For my own part, however, I have no doubt on the subject; and how the conglomerates come to have in their exposed masses any fragments of *Inoceramus* shells may, perhaps, be a little better explained now. Having just seen that the pebble beds and the masses of the chalk marl give fossils which are decidedly of secondary age, I again examined that mass of conglomerates which had so nearly been the cause of my not rightly understanding these beds. By looking at it carefully, I noticed that it contained fragments of the concretionary masses contained in the white marls; and, as I traced similar masses of conglomerates along the shore, it seemed to me as though this rock had been detached from a bed of conglomerate overlying the greensand, and hence both might be unconformable and younger.

24th March, 1874.

Spent part of the day in breaking the large mass which I mentioned in my last as containing *Inoceramus* shells, but did not very well succeed in getting any good specimens. I, however, brought away with me several fragments to prove the large size of the shells, and also to show that they were a different species to the *Inoceramus haasti.* From the absence of the concentric rings, and the presence of other characteristics, I should think they are the same as those large fragments found at the Amuri Bluff. I did, however, also get many fine specimens of *Inoceramus haasti* from another block, and also, from the same place, some small but indistinct shells.

Going along the shore to the north of Awanui, I examined the section and masses on the beach for Saurian bones, but without success. I brought back with me further samples of the black bituminous shale, and procured several fossils which I had not seen in this part of the section before. In the afternoon I went south as far as the greensand rock, but I found very little, except, perhaps, some few very good specimens of *Inoceramus* and one of a *Belemnite.*

28th March, 1874.

The further examination of the coast shows that between the mouth of the Waiapu and the Awatere Bluff there are no fewer than six synclines, all of which have an overthrow to the north. The greensands, as you are aware, clearly form a syncline at Awanui; and at the point of their occurrence further south I have placed them in a like position. It is evident, however, that this is a deeply-buried syncline, as no part of it appears above the surface exposed in section, all the beds exposed having a S.W. dip. That it must, however, be such, I hope to be able to prove. On the hill further south, whence came the great slip, the greensands pass along its N.E. face, and seemingly pass under the bituminous limestones and contorted sandstones exposed in the face of the slip. This proves that they are not the upper greensands, as in the corresponding section at Awanui we see the upper greensands resting on the chalk marls. On the beach, nearly half the south side of the syncline—the upper bed of which is the greensand—is hidden by slips, in which the presence of bituminous shale is apparent. I must confess this is a puzzle to me, as on the hill it seems to have a closer relationship to the greensands than to the chalk marls on the crown and south slopes of the hill. Further south of Awatere, little can, with any degree of certainty, be made out, on account of the enormous slips which are at present being denuded by the sea. At one point only are rocks to be seen which may, in any probability, expose correctly the strike and dip until we come to a creek which is more than half way between Awatere and Roporua. The rock in question is a fine-grained conglomerate with sandstones, sometimes green—almost greensands. This I at first mistook for the true greensands higher up in the series; but this idea I have now wholly given up, as it turns out to be the fine-grained conglomerate with the fragments of *Inoceramus* shells, the same as exists between Roporua and Tuparoa. It is here dipping south, and the next rocks seen are chalk marls dipping north; these are underlaid by the bituminous limestones, which, nearer to Roporua, are underlaid by sandstones. This anticline brings to the surface rocks lower than any yet seen in the north end of this section—*i.e.*, the blue sandstones with the large concretionary masses, which, at Roporua and further south, form such a prominent feature of the shore line. These are the same beds as come to the surface in the middle part of the section at the east head of Poverty Bay, and form there the axis. These concretionary sandstones again occur a mile further south, and a yet lower rock forms the axis—*i.e.*, a peculiar green tufa rock, which is seen nowhere else in the district. It is without fossils, and, where exposed, lies nearly flat; the sandstones with concretions dip away from it on either side, and, in both directions, the boulders on the beach contain gigantic shells of *Inoceramus*. A curious fact connected with these concretions is that—due, as they evidently are, to the presence of organic matter—they very seldom enclose any trace of an organism; but they have, on their under surface, fragments of shells adhering, or cemented by a fine calcareous matrix which is perfectly distinct from the rough sandstone mass lying above, it and showing cone-in-cone structure. In this vicinity I collected some *Inoceramus* shells, and I also took notice of others of very great size; some of them could not have been less than three feet in length. The animal, however, had apparently a very thin shell—a shell which was eighteen inches in length being scarcely more than a quarter of an inch in thickness; while I also saw parts of shells which were one inch in thickness, and which implied a shell of much greater size, even if it were granted that the portions I saw were much nearer to the umbone than the large fragments which I collected. The coast line here, as also further north, is to a large extent occupied by the material of large slips;

but, by observing the recurrence of the material of the different beds, it is not at all difficult to make out that there exist at least three anticlines, with their corresponding synclines, between Roporua and the junction of the newer and unconformable beds, and it is well worth noticing that all these anticlines bring to the surface the concretionary sandstones which never appear in the section north of Roporua.

A few hundred yards north of the most prominent point of the coast—between Tuparoa and Roporua, and near to a hut—blue marls make their appearance, and occupy a part of the coast line for a distance of about a mile. They are the same as on the south side of Tuparoa Bay, containing *Pecten zitelli*, and *Leda*. These beds do not seem to have that shell here, although they do contain other shells which are common to the south side. It is chiefly on account of a bed which contains abundance of *Nummulites* of three or four species, and from which I made a good collection, that the fossils of this outlier deserve notice. Though of a great thickness, it cannot be of very great extent superficially, as there are no signs of it to be seen along the track over the hill. Moreover, a creek which is near to the pa, and where the track rises over the hill, although it leads from behind the blue marls, and is not a quarter of a mile from the shore, brings down nothing but older rocks. Near by the hut, also, the strike of the hard sandstones would cut it off to the seaward and confine it to but little breadth. Masses of grey sandstone, which weathers brown, are to be seen capping the hill in broken boulders, many of which have found their way to the beach. This sandstone is found at the base of the formation, and also in beds considerably higher up, as shown in the coast between Tuparoa and Whareponga, and at this latter place contains fossils, though here I could not see any. These *Leda* marls, or *Pecten zitelli* beds, have their north side in contact with the green sandstones associated with bituminous limestones that underlie the chalk marls, and, on the south side, with the chalk marls themselves, showing a marked contrast between the material of the marls and the concretionary sandstone. The chalk marls are found in the valley of the Tuparoa Creek, a quarter of a mile from the beach, and also on the shore at the pa. The underlying beds are bituminous limestones with shales, and then the whole forms a syncline —as on the isolated hill behind the accommodation house—having as its upper member the coarse conglomerate with *Inoceramus* shells in the rolled material. On the south flank of this syncline rest the younger

Pecten zitelli beds, the line of junction striking S.W. 35° near the coast, though inland it seems to make a semicircular sweep from this point to Akuaku. The older chalk-marl beds rise into a mountain of nearly 2,000 feet in height close to the boundary of the younger series.

TUPAROA, 29th March, 1874.

Further examination shows the *Leda* marls south of Tuparoa as far as Whareponga—if not as far as Ropata's pa—are the *Pecten zitelli* beds. I have not yet discovered the source of the coarse conglomerates which contain the rolled fragments of concretions—the waste of the chalk marls. These fragments contain *Inoceramus* shells, and their appearance in the matrix, as well as in the rolled masses, convinces me that it must be a conglomerate which belongs to the chalk-marl series rather than to the *Leda* marls. This supposition is in part confirmed by this conglomerate being found in the big slip at Tuparoa, where, with the exception of itself, not a fragment of the younger rocks is seen. The greensands present the same difficulty if you attempt to classify them as part of the *Leda*-marl series, and nothing remains but to make them a separate formation by themselves.

As the state of the tide was favourable, I followed the beach from Tuparoa round the bluff to the south, as far as Whareponga, making collections from the *Leda* marls and greenish-grey sandstones which are interstratified therewith. I got numbers of very fine fossils, which showed the near relationship of the beds to the black marls under the Cobden limestones, and also to those at Christie's, on the Buller River. Besides *Pecten pleuronectes*, I got various forms of corals, including *Turbinolia;* also *Dentalium*, *Leda*, and others, all of which appear in the marls at Christie's. I got also a fine specimen of a large *Fusus* which I had not seen before, and a decided *Trigonia;* it, however, is very small, being less than 1¼ inches in length and breadth. The beds themselves form a syncline between Tuparoa and Whareponga, which strikes nearly north and south, and has a coarse sandstone at its base, though whether this bed is the lowest of the formation remains yet to be seen. Some thickness of blue marls without concretions is followed, in ascending order, by a considerable thickness of similar beds with concretions, and these, as seen at the point south of Tuparoa, contain immense shapeless concretions. The thickness of the marls alone must be something considerable here, as they are seen on the coast, near the point, to form the whole mass of the hills, which are not less than between 400 to 500 feet high. Not quite so good an estimate of their thickness can be formed at Whareponga, as a great part of the east side of the syncline is under the level of the sea, and the beds lie pitched at a considerable angle.

I returned to Tuparoa by the inland track, making some collections from the cutting dug along the road, which yielded a few fossils. I also made collections from the creek by which the track comes down to the beach.

30th March, 1874.

Packed the specimens from Roporua, including a very fine, large specimen of the *Inoceramus.* I also collected *Nummulites* from the *Leda* marls north of Tuparoa, which are mixed up with small univalves. In the afternoon I went up Tuparoa Creek, my object chiefly being to make out with certainty the position of the coarse conglomerate, which, as before mentioned, occurs in great plenty on the beach here, and in a big slip in a hill behind the pa. I succeeded in my object so far as to leave no doubt as to its true position. I found in the creek bed, first, the dark-coloured limestones and shales underlying the chalk marls, between which lay beds of fine-grained conglomerate and greensand, almost, indeed, altogether greensands, like those with the fish remains south of Awatere Point. The chalk marls have here concretions of great size, and forming, as they do, a syncline, are evidently unconformably overlaid by the coarse conglomerate, the creek here being filled with great masses of it; just beyond, where the lower beds again appear, it is comparatively scarce. In this creek there is hardly a trace of the *Leda* beds, there being merely a few sandstone masses broken away from the face of the hill to the south, the base of which is formed of old rock, while on its middle and higher parts, the *Leda* beds are present. The sandstones, which form the chief item in the coarse conglomerate, are beyond all question derived from the concretionary sandstone in the lower part of the chalk-marl series. These included sandstones often contain fragments of *Inoceramus* scattered through the matrix, which may owe their free condition to the fact that large surfaces of the shells are exposed by the splitting of the boulders, as may even now be seen on the beach. The shell, again, was easily separated from the surface to which it adhered, and thus appears in the resulting conglomerate as if it were contemporaneous with the accumulation of the same conglomerate. This is a fact which is not easy for anyone to comprehend unless he has seen the fossil shells as they are now found on the beach; but having once seen it, it will be directly apparent, from a mass in the creek which has all the appearance of the beds that immediately underlie the greensands.

I was lucky enough to hit upon a fossil fish in a good state of preservation, the tail and pectoral fins being almost complete. I will not attempt any description of it, but content myself with saying that, as a specimen, it is indeed beautiful, and far excels anything of the kind I have as yet seen produced in New Zealand.

I followed the creek up to opposite the saddle along which runs the road to Whareponga Creek, and found that a part of the younger beds here reach across the road almost to Tuparoa Creek. I returned thence by the road, and on my way home collected a few specimens from the beach.

31st March, 1874.

Having procured some specimens of *Inoceramus* from concretions brought down by the slip from the isolated hill at Tuparoa, I left for Akuaku, and arrived in the course of the afternoon. The remainder of the day I employed in collecting from boulders in the creek in the neighbourhood.

1st April, 1874.

In the morning I followed the main branch of the Akuaku Creek till I found that the material in the watercourse was composed chiefly of secondary rocks. I then returned, and followed the next branch to the north, but with only the same result, thus arriving at the conclusion—which I had previously inferred from the outline of the ranges—that the saddle between this creek and Whareponga consisted of marls underlying the harder sandstone beds, which are covered by bush of large size, the older rock having but a very stunted scrub on it. The lower part of the creek was full of fossiliferous boulders, and these occupied my attention.

I observed such a vast variety of fossils that to attempt any explanation of them would be quite useless. In the beds which overlie unconformably the *Leda* marls I found many forms I cannot recognise, together with a large *Dentalium*, which is a very plentiful fossil, and *Cucullæa*, also very abundant in the same blocks. There are also a few of the *Pectens* which form so prominent a feature in the creek at

Duncan's, south of Tawhiti. There is a very great number of univalves, and a good collection may be made here.

The secondary rocks found at the mouth of the Akuaku Creek are the greensand beds which occur in other portions of the section, though I see none of the pebble beds here. Concretions from the lower Roporua sandstones are plentiful in the creek bed, and, as far as I was able to judge, the indurated chalk marls also occur. The boulders from the lower, or Roporua, sandstone often have, as in the Roporua section, one side covered with a considerable thickness of cone-in-cone limestone, forming a slab easily separable from the rest of the boulder.

3rd April, 1874.

Went along the foot of the range behind Akuaku, but I failed to find the source of the fossiliferous blocks which lie in the creek; but later in the day, when you joined me, the *Cucullæa* beds were found in the precipitous scarp of the range, and also the argillaceous sandstones which overlie the *Leda* beds, and are also exposed in contact with the *Inoceramus* beds at the Pa and follow the ridge to the crown of the hill above Ropata's Pa. The beds which overlie the *Leda* marls consist of argillaceous sandstone, and contain some fossils which are peculiar to them in this locality. In the same beds is also a considerable variety of other shells, though, as a general rule, they are of but small size and very tender.

To obtain a connected section exposing rocks from the *Leda* beds to the *Cucullæa* beds, I went round to Whareponga. The strike of these harder beds is such as would bring them close to the argillaceous sandstones which abut on the *Inoceramus* beds at this place, and which coincide with some harder bands on the north side of Whareponga Bay. As soon as we have passed these sandstone bands, it becomes evident that we have to do with beds that are higher than the *Leda* beds, as plainly shown by the character and abundance of the fossils. The beds are also much darker in colour, and almost greensand. I obtained here *Ostrea*, *Cucullæa*, and some of the smaller bivalves; but to find the junction of the banded fossiliferous beds on the south side of the creek was my chief object. The upper beds seem to rest on the marls in the creek bed unconformably. Selecting a little creek which rises in the coast range where the slip occurs, I followed it up, but was unable to distinguish between the marls of the *Leda* beds and the fossiliferous tertiary rocks at their respective points of junction.

The first fossiliferous bed that I observed contained an occasional *Cucullæa* and other shells. In running the beds higher they led into land which had slipped, and thus there is found a very similar confusion of material to that which exists in the creek at Akuaku. Beds corresponding in character to the lower tertiary beds at that place followed the fossiliferous bands, and over that the only rock I could see was a sandstone of a fine grain, and a light-brownish sandstone, which, when it is not of this colour, is blue, as may be seen in a large slip a little further on. The peak on the south side of Whareponga Pa is 680 feet in height, and rises from the creek at an angle of about 40°. The top of the range is a kind of table-land, though very much cut up by gullies, which are excavated out of the soft material of the upper formation. I followed along the top of the range in the direction of the section behind Akuaku, but saw nothing further than this light-coloured sandstone, properly a blue sandstone, and the upper beds of the series.

I next made for the east end of the section exposed in the bold cliffs overlying Akuaku, and kept the top of the range for the whole length of the scarp. I found the highest peak—prominent on account of some trees which were growing on the far top of the cliff—to be 1,140 feet above the level of the sea, and to consist of the soft blue sandstone, weathering light brown, and here containing flattened concretions with the large *Dentalium* and associated shells; but I did not see in these upper beds any *Cucullæa*. The sandstone with the large *Pecten* must underlie the *Cucullæa* part of the series, but I did not see it excepting below the *Cucullæa* beds. On the west bluff of this range, and on the north-west side of it, a great slip has taken place in the upper *Dentalium* or *Struthiolaria* beds, and in the fragments which strew the face of the hill *Pinna* and *Dentalium* are seen. I cannot see that from the *Cucullæa* beds upwards any unconformity exists, as the beds seem to succeed each other in unbroken succession. They may, however, be divided into upper (or *Struthiolaria*) beds, middle (or *Cucullæa*) beds, and lower (or *Ostrea*) beds. Moreover, I should be of opinion that any collection which may be made in the light of this arrangement cannot but be made advantageously, and thus secure their proper separation in the case of an unconformity being hereafter proved. Descending from the range to the saddle between Akuaku and Te Wangaroa—which turns out to be the older rock, even on the very saddle—I followed down one of the lesser creeks, and in the afternoon I collected in the creek from the beds which contain *Venus*.

4th April, 1874.

On the morning of the 4th instant I passed over the saddle west of the high bluff north of Akuaku, and followed along the range till I came opposite the source of the Whareponga, finding only the bituminous limestones and sandstones with *Inoceramus*, from which it was clear that on this side of the high ridge, which divides the streams that flow into Open Bay, there were no younger tertiary rocks. I found a Maori track which led into the bed of the Whareponga, and followed it. On reaching the bed of the creek, I found rock of a different character from any I had yet seen associated with the chalk marls, the nearest approach to them being seen on the west side of Tuparoa Hill, and in close connection with the coarse brown conglomerate was a light-grey sandstone, soft, and bedded with sulphurous shales, striking S.E. and dipping at a moderate angle. There were also in the bed of the stream many masses from the lower sandstone beds with *Inoceramus*, showing that these beds were exposed further up the creek. I however continued to follow this creek down in order to see where it made a junction with the younger rocks.

I found that none of the young tertiary rocks reach the bed of the Whareponga, as the older rocks of which I speak are exposed all the way down the creek to within a quarter of a mile of the junction of the branches from the north. Near the mission station *Leda* marls make their appearance—though old chalk marls certainly are again seen at the junction—thus preventing my seeing the junction between the greensands which overlie the beds mentioned and bituminous limestones and chalk marls at the junction of the two branches of Whareponga Creek.

As far as I have seen, the rocks in the bed of the stream higher up than the *Leda* marls are the greensands of Awanui, and these have here characters which are not to be mistaken, as they form a syncline, across which a section from the big hill capped by chalk marls on the north side of the valley would pass to Akuaku. The greensands which contain the white pieces of limestone are not wanting in these beds, and the rough conglomerate is also present. The banded character of some of the beds is very similar to the *Venus* beds at Akuaku. Fossils are not, however, found in the strata seen in the bed of the Whareponga. What becomes of the *Venus* beds I cannot make out, as they do not appear anywhere in the coast section between this and the Whareponga. This leads one to suppose that they may perhaps be unconformably overlaid by the blue marls, or *Ostrea* beds, at the base of the *Cucullæa* beds.

AKUAKU, 5th April, 1874.

I followed the greensands down the creek, and found, as I before observed, that they were succeeded—whether conformably or not I cannot say—by the *Leda* marls. These last I followed down until they brought me once more to bituminous limestones, greensand pebble beds, and chalk marls, at the junction of the two branches of the creek. Examined once more the tertiary beds on the hill opposite the church, but I was still unable to prove whether the *Struthiolaria* beds pass down unconformably on to the *Leda*-marl beds. One thing, at least, is certain, that these tertiaries, as here seen, pass down on to the older beds, not as a syncline, but in the manner in which I have sketched below.

I ascended Takoratea by way of its south-east flank. Leaving the track, and following a small creek which joins in at the junction of the two main branches of the creek, I followed it in a north-west direction, and soon came to a white chalky rock which cropped out in the banks of the creek and the adjacent spurs. In this I was not able to find any fossils, but its character as an indurated chalk marl left no doubt as to its identity. Here I got so bothered with the tall ferns and the scrub that I was compelled to break the section and make for the track, in order to get to the next hill in the line. Having done this, I found the stratification to pass down on to the *Leda* beds, and that the material overlying the chalk marls was a soft yellow sandstone, very difficult to distinguish from the higher members of the tertiary series as they are seen behind Akuaku, interbedded with grey crumbling clays, in no degree blue, like all the younger masses in this district, but nearer in appearance to the *Venus* beds than to any others in the district. This sandstone most certainly is overlaid by chalk marls, which fill the saddle between this and the higher peak. I found that this sandstone, where not decomposed, was of a green colour, and on the slopes and the top of the higher hill it was interbedded with indurated chalk marls. The whole of this, as far as I could see, was one side of an anticline, and the lowest rock visible is the conglomerate in the creek bed and its associated Awanui greensands. The chalk marls which are interbedded with the green sandstone do not contain either concretions or boulders; it is just possible, therefore, that they lie on the greensand unconformably; but that this is the case I do not myself think. In following the creek at Whareponga this will be seen, as, if these chalk marls of Takoratea do in reality underlie the greensands, they should be found in the creek bed, but there is no appearance of them; on the contrary, all the evidence in the creek bed tends to show that the rocks which are higher up the creek are yet lower in the series—such, for instance, as boulders with *Inoceramus* and cone-in-cone structure.

I found that the mountain of Takoratea was 1,680 feet high, and from the summit a fine view is to be obtained. Hikurangi is seen to the best advantage, and two other peaks of very rugged appearance are also very prominent objects in the view, one of the smaller hills on its south-west side being a sheer cliff. The right-hand branch of the Waiapu runs straight away to the south-west, and the view of the low spurs falling from the watershed on either side, with the distant range crossing the valley at its source, although not comparable with Hikurangi, is yet of great beauty. It, however, far excels anything that can be seen from Tawhiti, as, at the latter point, the high range to the west interferes.

If I can establish the fact that a great succession of chalk marls overlie the greensands and conglomerates of Awanui, it will be a very interesting fact in connection with the greensands and conglomerates, as it has hitherto always appeared to be a mere fragment of a formation.

To-day I also examined part of the range on the north-east side of the creek near the church, and found that the marls there underlie the *Cucullæa* beds. I had no difficulty in distinguishing between the *Leda* beds and those of which I have just spoken, as the fossils themselves indicate the difference.

6th April, 1874.

The section from Akuaku to the top of Takoratea will, I think, be of interest; but, as a description of it has already been given, any further account will be unnecessary.

The *Leda*-marl beds, without any doubt, form a syncline between the point of their appearance in the Whareponga Creek and on the coast at Ropata's Pa; but the same awkward arrangement still remains for the younger beds, namely, that the upper overlaps the lower beds and abuts against the north-west exposure of the *Leda* beds.

I went down to Waipiro, and on the beach, in the section from Akuaku to Waipiro, I saw, first of all close to Akuaku, the greenish contorted sandstone dipping N.N.E. At the next point I found the chalk marls, but they did not contain any concretions. In the bight between this and the next reef an anticline must take place, as at low water similar beds are to be seen, which dip S.S.W.; and half-way between Akuaku and Waipiro they become vertical and have also small concretions in them. At the first point from Akuaku, one might at a glance easily mistake the chalk marls for younger beds. Passing the anticline about half-way, I did not see anything till I came close up to Waipiro, where a reef of rocks runs out to sea, still dipping S.; and on a hill behind the store some soft, crumbling shales, very like the *Leda* beds, are seen; they are, however, crumbling chalk marls with concretions.

After I had reached this point, I followed up the creek bed, and soon came to a blue marl cliff (*Leda* bed). I did not, however, find any fossils in them, except a few *Nummulites.* A little further up the creek I saw in its bed the green sandstones of the older series. These underlie some immense concretionary boulders in the creek bed, and show that the concretionary chalk is not far off. I observed masses lying in the bed of the creek which had in them fragments of *Inoceramus* and a great number of fine specimens of cone-in-cone; but my attention was chiefly attracted by a very peculiar yellow semi-crystalline limestone. This contained some fossils, which, from what I can make out, I believe to be the same as those that are found in the limestones near the mouth of the Waiapu River, and coral beds in the cliff behind Akuaku. Great quantities of this limestone, in large blocks, are found in the bed of the creek further up, and seem to be almost entirely made up of the remains of the particular shell which I have mentioned. There are also in these blocks numbers of *Nummulites* and plenty of coral, which leave no doubt as to its identity with the beds behind Akuaku in which the same fossils are found.

It now became a point of interest to me to see from whence came these limestones. They would seem to be the beds which directly underlie the tertiaries; but in the Waipiro I could not anywhere find beds higher than the *Leda* marls (the blue marls mentioned as occurring in the mouth of the creek turning out to be such), and they are greatly developed in the upper branches of the Waipiro. There are not any of the older rocks that reach west of the first and main branch, and this branch turns back into the heights behind the Waipiro Hotel. At the junction of these two main branches, a little more than half a mile from the beach, there seems to be the source of the limestone, implying that it underlies the *Leda* marls. The dip of the *Leda* marls, which here make a junction with the *Inoceramus* beds, I could not make out, so that as yet the true position of this limestone remains a mystery. As it occurs just at and along the junction, it leads me to think that I might put it at the base of the *Leda* beds. I carefully looked at the same beds at Akuaku, and there they must be placed at the top of the *Leda* series. The beds west of the main branch of the Waipiro are, without doubt, *Leda* marls, as is testified by the appearance of *Pecten zitelli.* A green tufaceous conglomerate, identical with that at the base of the *Leda* marls at Christie's, Inangahua, occurs along this junction.

I followed the south branch of the creek, thinking that I might find a way out of my difficulty in that direction, but I could see nothing here except *Leda* marls without stratification. I tried the north-west branch with a like result, the limestone boulders gradually disappearing, and the creek bed having concretions from the marls instead. The north-east branch, striking away from the junction, quickly ran me through the greensands and shales to the underlying concretionary beds. I saw none of the soft blue sandstones of the Roporua section; but, as there was no lack of masses which had cakes of cone-in-cone attached to them, I should from this be inclined to the belief that it was not far off, if not represented by green sandstones in the creek banks.

From the basin, from which this branch of the creek rises, I crossed the spur, and so returned to Akuaku. I did not observe anything of consequence but the occurrence of the *Inoceramus* beds on the ridge to the seaward; and I also saw that the line of junction may be traced along the middle branch of the creek almost to its source. In coming along the beach I observed that there must exist in the older formation two anticlines between Waipiro and Akuaku, and I noticed, also, the chalk marls in the resulting syncline.

7th April, 1874.

I happened this afternoon to come upon a slab which was full of *Pinna* in the most beautiful state of preservation. I cannot hit upon any more of the new coral, but am bringing every fragment that I can get from the original block.

8th April, 1874.

Took horse, and, after crossing the saddle, reached Whareponga Creek at the point above which the nature of the rock in its bed was unknown to me. When I started I expected a great deal from following up this creek, but the slips close it in on all sides, and obscure everything. The rocks which cause this confusion are, as is usually the case, the bituminous beds which underlie the chalk marls; but the section is clear enough in a general sense, as it is partly seen along the beach to Waipiro and back again up its north-east branch. This part of the section exposes two anticlines, one of which brings up the lower *Inoceramus* beds, while that nearer to Akuaku does not expose anything lower than the beds which directly underlie the chalk marls. In contact with the chalk marls, and dipping to the S.E. at an angle of about 80°, are the beds corresponding to those *Venus* beds behind Akuaku, and they clearly form a syncline in the section exposed in the bed of the creek just opposite to the mission station. As I looked at the markedly stratified *Cucullæa* beds on the higher portion of the range, this arrangement seemed to me to be a very puzzling one, as this upper bed would seem to pass down on the *Leda* marls, and it is the upper bed only that would appear to be the unconformable one.

I had already ascended the seaward peak of this section, and therefore, in order to make sure, there remained nothing for me to do but to get to the top of this one also. It is a wonderful peak in its way, as from its base we have chalk marls with greensands, higher up are the *Leda* beds, and the top of all is crowned by the *Struthiolaria* beds. I was very glad that I did go to the trouble of making the ascent, as once there I could see that the question as to an unconformity between the *Leda* and the overlying *Cucullæa* beds, both here and at Akuaku, was fairly settled, the more so as I see that by your sections from Tokomarua I could scarcely have made the matter out there.

To the tertiary beds on the beach close to Whareponga I gave close attention, and it is my opinion that their presence there is due to a huge slip which has taken place from the higher part of the hill, and I fancy the planing action of the sea has caused it to have the appearance of being in place where it now lies. That it is quite local is evident from the fact that the *Leda* beds are on either side of it, so that the occurrence of a small patch scarcely one hundred yards in breadth need hardly be taken into consideration.

Two creeks of small size leave Whareponga. They take their rise in the younger beds, and I followed them back again to see if the lower *Cucullæa* beds came through to the north face; but I was forced to come to the conclusion that they did not, and this, too, in the face of the fact that the *Leda* marls do not there gain the elevation they do a little further down the creek.

The greensands and the conglomerates in the valley of the Whareponga I am not able to make anything of at present, but that they still seem to stick to the companionship of the chalk marls and also to the vicinity of the *Inoceramus* beds.

WAIPIRO, 9th April, 1874.

I observed that from Waipiro Creek to the Pa (south) the rocks, as a rule, are the green sandstones which overlie the chalk marls, and that the brown sandstones at the Pa, to which I have drawn attention, belong to the newer series, and are, in fact, the brown nodular sandstones of Tawhiti. This, however, is but an outlying bed, as the chalks with concretions lie between it and the main mass south of the creek.

Procuring a guide to the hot springs, I lost no time in making a start, but at once took the spur which led in that direction. Over a great part of the distance concretionary masses of the chalk marls were to be seen on the surface, and these older rocks were the only ones that I could see all the way; if the younger rocks do exist anywhere here at all, they do not show. There is no hill between this and the coast line which is formed of any other than these older rocks. From this it would seem that the *Leda* marls at the head of the Waipiro were merely an outlier, as the ridge on which the hot springs are situated is composed of upper chalk marls and the conglomerates of the Awanui greensand, and I should think that it formed the watershed between the Waipiro and the creek which falls to the west. I picked up a piece of conglomerate at the hot springs, which is some foundation for this argument.

From the high ridge between this and the next creek to the south, the upper part of the Waipiro looks like a circular depression, in which one would almost look for a remnant of the younger beds.

Having secured samples of the water from the springs, I returned by the leading spur, which terminates on the south side of the Waipiro, expecting to see on it some traces of the *Leda* marls which are to be seen such a short distance up the creek. I did not, however, see signs of them anywhere, the chalk marls with concretions being on the top of the hill, and at its base the green sandstone, and yet scarcely a trace of these rocks is to be seen in the north-west and south-west branches of the Waipiro.

In the afternoon I went on to Tuparoa, as it was my intention to see next day the coal which was reported to have been discovered up the Waiapu Valley.

TUPAROA, 11th April, 1874.

Shortly after daybreak I left Tuparoa, and struck inland. Chalk marls, as before mentioned, are found near the mouth of Tuparoa Creek, and the same beds, and also bituminous limestones, are found as far back as the watershed of the saddle dividing it from the creek by which we reached the Waiapu, the flat of which is mostly alluvial. Reaching the river at Manutahi Pa, we followed along the bank till near the junction, where we crossed, close to another Pa. At this point I observed in the river bed boulders of the coarse conglomerate containing *Inoceramus* fragments, etc. I could hardly have expected to see any of the greensands, they being material unable to resist much pounding, and consequently was not disappointed at their absence. The big slip in the forks of the river—so conspicuously visible from the road between Tuparoa and Roporua—consists of chalk marls, while in the bed of the left branch of the river the large, brown concretions of these rocks are plentiful.

Soon after this we left the river bed, and galloped along the rough bush country at a round pace till opposite the first rugged mountain mass, where we again came into the river bed, and yet we had the boulders of the chalk marls, though the marls themselves seemed to be absent. Dark limestones and shales were here the rocks which were exposed in the river bed; these with green sandstones forming here, as elsewhere, an underlying bed for the chalk marls. Those I saw at this place, however, seemed to contain concretions, also implying that they are occupying an horizon equal to Awatere Point, while over them lay a considerable thickness of the black bituminous shale. On seeing this I anticipated its turning out to be the coal of which I was in quest, but, to my great surprise, the native rode by it, merely remarking that the coal was further up the river. On his asserting that if we slackened our speed we should not reach Tuparoa till considerably after dark, despite the increasing difficulty of the road and the stony nature of the river bed we rode on at a headlong pace. I saw nothing in the river as far as we had yet gone to lead me to believe in the existence of older rocks than the chalk-marl series in the bed of the river. In several places I saw fragmental *Inoceramus* shells, but every rock I noticed in the bank consisted of blue contorted sandstones and limestones with shales.

Just opposite the base of the mountain on the north-east flank of Mount Taitai the native pulled up, saying that coal occurred in the opposite bank of the river. I could see no difference in the rock here from what was visible further down. On inspection, however, I found it to consist of dark shales and limestones highly contorted, and having concretions, without, however, the faintest trace of coal in it. Riding another mile and a half, I found merely a repetition of the same material which I mentioned just now as occurring at the supposed coal seam.

As I found the native willing to proceed further still, we pushed on as far as was consistent with the idea of returning to our starting-point the same evening. I observed no change in the character of the rocks as far as we went, and, from their strike, we evidently passed over those at least which form the flank of the mountains north-east of Hikurangi itself. After crossing the river at the forks, we passed at least one anticline and one corresponding syncline; and, as we left the coast on the syncline of Tuparoa, this would make the big hill behind Whareponga, with its three peaks, come in a line with the same anticlinal ridge, whereas Hikurangi must belong to a line of strike further to the south-west. I deem it notable that along the first line the upper rocks of the series form the crown of these several heights. I was on the top of the first of these heights behind Whareponga, and saw that there the chalk marls and rocks—in all probability higher than any I had observed anywhere else—formed the higher parts of the hill. The next peak in the line—noticeable from the fact of its having a sheer precipice of great height on its south-west side—has chalk marls on its south-east side at least, though the mass of it seems to consist mostly of the dark shales and limestones lying beneath. As I observed, at a great slip in its north-east face the strata dip to the west, and, as a consequence, the eastern flank contains the actual anticline. The second line of peaks just takes in the mountain on the north-east flank of Hikurangi, the nature of which I have already described, and passing on from there brings fairly within the line a mass of mountains in height equal to Hikurangi, standing to the north-west of it. On these I was near enough to see clearly the light colour of the rocks of chalk which appeared more than half-way up it.

The weather, which had long presented a threatening aspect, seemed to point out our speedy return as the best course we could pursue, and this we had hardly decided to do when rain began to fall. Long before we crossed the Waiapu we were wet through, and about dusk got to Tuparoa.

AKUAKU, 13th April, 1874.

To-day I went to the creek south of the Waipiro, which runs along by the junction of the chalk marls and the tertiary formations. While the tide was still low I went as far along the beach as I could get, hoping to see the rocks at the south head of Open Bay. I did not, however, reach the very point itself, though I went far enough to make myself quite sure as to what really was the nature of the rock. I have already mentioned that the sandstones at the Pa belong to the upper nodular sandstones of the tertiary series; and, though there they have no fossils whatever, a little way further up the creek the nodules are full of fossils characteristic of the upper beds at Akuaku, such as *Dentalium*, *Struthiolaria*, etc. As you go along the south side of Open Bay it is not greatly out of the strike of the Akuaku beds. I did not, therefore, get very soon into the lower beds, and in fact I never caught sight at all of the *Cucullæa* beds, though at the same time I must have been very close to them, as they form, in all probability, the south head of the bay. As you follow from the south head backwards, round the bay and up the creek that drains the hot springs, the strike and dip gradually change, till—while at the south head the dip is to the N.W.—half a mile, or a little more, up the creek the strike and dip are to the S.E., and thus they form a syncline, which is perfect for not more than half a mile, after which only the east side remains.

It is very remarkable how closely the different formations have their boundaries confined to some creek coinciding in their direction with the strike of the junction; this, with others, being an example, having for more than a mile from the mouth chalk marls on the one bank and tertiaries on the other. After this distance the chalk marls cross to the south side of the creek, but, being overlaid by the tertiary rocks, these appear further up as an outlier on the north side of the creek. There is in this creek a very large development of greensands and coarse conglomerate in close connection, and these are so interstratified with the chalk marls that there can be no doubt left on the mind that they are contemporaneous, and that, wherever the unconformity does take place, it must at any rate be deeper than this portion of the chalk marls. I have not anywhere previously seen so great a development of greensands and conglomerates as takes place here. There is also a greenish chalk-marl resembling that at Rocky Point, Awanui, which has large boulders in it, and the whole is so interstratified with the true chalk marl, which has for its only fossil flat tubes in large brown concretions, that I cannot resist the evidence further. There is also here the bituminous shale in considerable abundance, and this seems to me to be another associate of the chalk marls. In some cases these shales are soft, just as they are at Awanui, and in other cases they are hard and indurated as those at Tuparoa. From the effect of great slips up near the hot springs, these rocks get mixed in great confusion, but they seem to run on to the west, right through to a big creek that falls into the Tokomarua Bay at Arthur's Station, and to be at least one mile and a half S.E. of the hot springs before the tertiaries begin. Hence the hot springs clearly lie within the chalk-marl series, at least the vent is, though the artesian source itself may be either in the *Leda* marls or the younger tertiaries.

I picked up at the hot springs a piece of conglomerate, which would show that the springs are situated in the conglomerates of the Awanui greensands, and this is rendered probable, as in rocks of that age this would be, from the strike in the creek, the very member to expect there.

TEPUKU, 16th April, 1874.

On the morning of the 16th I crossed Tawhiti, and took notice of the several members of the formations which form its mass. First, the upper beds, consisting of brown sandstones, which more properly are blue sandstones weathering brown. These are the *Dentalium* or *Struthiolaria* beds, though fossils of any kind seem to be either totally absent or very rare along the track, but, as I have already mentioned, they are plentiful on the beach and up the creek at Waikauri. However, after passing the peak, and on the descent towards Tokomarua Bay, we find, first, the *Cucullœa* beds close to a waterfall on the edge of the track, and, a little further down the hill, the *Ostrea* beds begin, but they are suddenly cut off by a bed of loose white sand. This is the lowest bed of the tertiary rocks, and is directly succeeded by marls, which, I shall be able to show, are the *Leda* beds. These marls and sands are seen on the last shoulder of the spur whereby the track descends. I got one or two excellent fossils from the *Cucullœa* beds as I came down the track, and I also procured what I believe to be a new one altogether. I also observed that the sequence of the fossils was exactly as I made it out at Akuaku. The occurrence so suddenly of the *Leda* marls, I must admit, rather puzzled me, as I fully expected to see the succession complete right down to the lowest beds of all. I had not the slighest hesitation in recognising that these rocks belonged to the *Leda*-marl formation, and corresponded in horizon with the basement beds as seen at Tuparoa and at the first point north of Whareponga, and again about half way between there and Ropata's Pa, on the point half a mile north of Akuaku. The rock here is very characteristic and not to be mistaken, and, even if further proofs were wanting, they would be at hand in the concretions peculiar to the *Leda* marls, as also to fossils contained in the marls themselves, namely, *Nummulites* of a peculiar character, etc., and a *Dentalium* with a compressed mouth, small *Leda*, etc. These were all the fossils I was able to find, but they were just such as I should have expected to find. I next pushed along the shore to the Big Head, as I may call it. There is a creek which takes its rise east of the peak of Tawhiti falls, and falls into a little bay formed by these two points; and about 150 yards beyond the creek the junction of the *Leda* marls with the younger tertiary rocks is plainly to be seen in section. There is about 30° difference in the strike, and the dip also is not the same. This, with the complete change of material, makes this junction marked enough to be sufficiently decisive.

I followed round the headland of the Bluff to the point which projects furthest into the sea, and I still found that the lowest rocks which I could see were the *Ostrea* beds. From masses on the beach I collected fine specimens of *Cucullæa*, *Ostrea*, *Pectunculus*, and a new shell which I have not before seen anywhere except in these beds. I also found fine specimens of a small *Turritella*, the long thorny volute, and *Ancillaria*. I next pushed on as far as the accommodation house, where, in the afternoon, I went up the small creek behind the house, as I wished to see if the *Leda* beds came along the base of the hills with the tertiary rocks forming the tops; the conclusion arrived at being that a narrow strip of *Leda* marls only skirts the shore of the bay. I was shown a bit of rock taken from the vicinity of the newly-discovered gas springs west of this bay, and, without doubt, it belongs to the chalk-marl series, to which it would seem that all these gas springs belong, and that they are always in such rocks as would bespeak the near presence of bituminous shales.

TOKOMARUA, 17th April, 1874.

On the morning of the 16th I followed up a considerable creek, which, after taking its rise in the conical mountains of the hot springs, falls into the Bay of Tokomarua, not far from the school-house and the adjoining Pa. This creek is full of masses that contain fossils, which, however, are chiefly from the lower and middle tertiary beds, although, at the same time, there are also many fine examples from the upper bed. The *Turritella,* which seems to be rather scarce at Akuaku, was frequent a little further up the creek, and in a very good state of preservation; indeed, so plentiful was it that it formed masses of which it was the sole component. The mouth of the creek has *Leda* marls on both sides, which continue on up the creek and on the low hills to the west. About three miles up the creek I came to the gorge which is formed by the Tawhiti or tertiary range. I cannot say, however, that I did really see any signs of tertiary rocks at all in the bed of the stream. The erosion of the creek has laid bare the *Leda* marls which underlie, and which consequently pass, as a narrow strip exposed in the bed of the creek, right through the gorge to the less hilly country S.W. of the hot springs. I followed up the creek till I was nearly abreast of the source of the creek which dams the hot spring. I had seen the *Leda* marls all the way along in the bed of the creek, and, though the rocks in the bank certainly were *Leda* marls, yet the shingle in the bed of the stream itself showed various signs of the near presence of the chalk-marl series, and as the chalk-marl series consists of chalks, greensand, and conglomerates, and is, I think, proved to come almost to the bank of the creek along the line of its junction with the tertiary rocks, I cannot make out these *Leda* marls at all, unless they be a narrow basin connecting with the *Leda* marls in the north-west branch of the Waipiro. I also got in the creek a good deal of the black crystalline volcanic rocks which are found in several localities on this coast, and which seem to belong to the chalk marls.

I went at low tide on to the beach, and was very much surprised to find a rock which was quite different from the usual character of the *Leda* marls. This rock consisted of marls, which were interbedded with sandstones irregularly laminated. I have up to this time called that kind of sandstone contorted, which looks very much like the sandstone that underlies the concretionary marls at Poverty Bay (McDonald's). These rocks contained great quantities of flat tubes and coiled *Nummulites,* also some fragments of sea urchins and something like a kind of small *Pinna.* They were very much contorted in their strike, but were, on the whole, striking from 40° to 50° N.E. and S.W., with a dip to the N.W. of from 35° to 40°. These are, therefore, lower in the series than any *Leda* marls north of this as far as the Waiapu River.

DUNCAN'S, 24th March, 1874.

Followed the middle branch of the Waipiro to its source, and thereby proved that there was a very considerable development of *Leda* beds to the north-west of the hot springs. As I was returning I crossed the Tawhiti, and noticed great difficulties in the way if I attempted to reach the summit of the conical hill from that side.

On the morning of the 21st I left for Duncan's, and about a mile south of Arthur's place, on the beach, I saw great masses of greensand; and a huge slip of the lower beds which are exposed on the hill directly above this place shows the source whence these masses come. The slip also exposes a curious light-grey rock, which is very similar to the rock at the Gable End Foreland, and this, with the quartz sandstone, immediately overlies the greensand beds, the latter being underlaid by marls, both blue and of a dark colour, but in these I was unable to find any fossils. A little further south along the bay a blue sandstone makes its appearance at sea level, and strikes N. and S., with a low dip to the W. After this I was not able to see anything very distinctly until I had passed the Pa; there the track leaves the beach. I now went along the beach towards the south head of the bay, but was not able to find anything. Only the marls which I have already described were exposed on the beach. These were capped by the beds of greensand, and, as far as I can judge, it is the same set of beds, which apparently runs out to the very point. What the beds were composed of was so evident that I did not think it at all necessary to go to the very point itself, and therefore I returned again to the track and proceeded on my way to Duncan's. I saw brown sandstones in the cuttings of the roads along the track; the fossils, however, were very scarce, though any that there were resembled very much those fossils which are to be found in the tertiary rocks.

There is nothing worthy of much notice till the track again reaches the beach, which it does near a Pa; and here, on the beach and bluff to the north, are blue sandstones with crumbling shales between. These rocks were striking due S., and dipping N. at an angle of 15°; they contained carbonaceous streaks and many small fossils. There were also any quantity of tubes (round tubes), and these, combined with the general character of the rock, led me to consider them to be *Leda* beds. On the beach at the mouth of the creek, washed down from upper beds, I found that the masses contained *Natica* and the larger *Dentalium*, and many of the other fossils also which were common in the Akuaku beds. The quartz grits, which however do not contain any fossils, are underlying these sandstones, which I have just described, and are exposed on the hill on the south side of this bay; and, as far as I can see, rocks of a similar nature to those which overlie them underlie also the quartz grits of which I have just spoken, and still dip to the N. When I had crossed this hill I came to the beach a little north of Duncan's, and in the point to the north-east of Duncan's the beds are nearly level; they, however, still dip to the N.

On the 22nd I made collections on the beach at Duncan's, and succeeded in getting together a very good lot of fossils, most of them from the *Pecten* and *Ostrea* beds. I, however, got some new forms too. Among others I found a large shark's tooth, which I got out of a huge block that was full of *Pectunculus*. This tooth, which is identical with large teeth from the Curiosity Shop in Canterbury, is fully 1½ inches in width at the base, and is serrated on the edges, the very point itself being broken away. I certainly did find *Dentalium*, though not in the abundance I had expected to find it; and, though *Natica* and *Struthiolaria* are not scarce, they are very far from being so plentiful as they are in the beds at Akuaku. The very small *Dentalium* is, however, very plentiful here, and I also found one *Murex*. I think I mentioned in a former letter that I had found one of these latter (*i.e.*, *Murex*) at Akuaku.

In the rocks which yield the small *Dentalium* there are also a good many *Volutes* and a small *Turritella*.

On the 23rd instant I took the face behind Duncan's, and ascended the big range (this range runs on from here in a continuous line to Arthur's place). This I did, not only with the view of finding out the sequence of the sections as they are there seen, but also to enable me to make a guess at the nature of the country behind. While I was ascending the big range I could not see anything till I had reached an elevation of 500 feet above the level of the sea; then the white, gritty sandstone made its appearance, and I suspect that there must be another bed also still higher up the mountain, from the appearance of the fragments which I saw on the slopes at a greater elevation. Grey, crumbling, sandy beds (which are the same characteristics the marls have that underlie the *Ostrea-Pecten* beds at Akuaku) occupy the middle part of the mountain, and these are overlaid by the *Ostrea-Pecten* beds, which here reach a level of 1,400 feet above the level of the sea, and form the lower end of the range behind Duncan's. Peaks further to the north have a still greater elevation of about 300 feet, and are, in all probability, capped by the *Cucullæa* beds. All through the range the beds are nearly horizontal, and the horizon of the greensand beds, which is clearly marked, makes it of very great importance in the estimation of the total thickness of the series. At Akuaku the greensands do not form any regular bed, but are only as elliptic masses at the base of the *Cucullæa* beds, though their position is defined clearly enough, underlaid as they are by the well-marked *Ostrea* beds with the fan corals. The dip of these beds at Akuaku would bring them quite under the sea level before the peak (1,143 feet high) with the tree on the top of it would stand vertically over them, and thus the entire height of that hill, after deducting the angle of dip, which is about 35°, when added to the vertical height of the hill behind Duncan's, will still be considerably within the mark of what is the real thickness of the formation. Its entire thickness I am as yet only able to guess at, but it will be a great deal thicker than it would seem to be from the *data* I have just given.

From the top I observed to the west a mountainous country of a most broken character, which clearly showed, from the outlines of its features, that it belonged to the tertiary rather than to the secondary rocks, the scarps of which are far more precipitous in the broken cliffs. Some of the lines of stratification can be seen from a very great distance, and there is a marked difference between the gently undulating hills of the chalk-marl series and these rugged and rough hills, which are of quite a different character. This rugged country strikes away to the N.W., and has a high mountain close on its western boundary. West of Tolago Bay some bare, white bluffs may perhaps be secondary rocks, though more probably white quartz grit.

25th April, 1874.

On 23rd April I still continued to collect at Duncan's, and I also paid a visit to the two bluffs which lie on either side of the little bay. On the bluff to the south the white quartz-grit sandstones crop out at an elevation of about 450 feet, and the rock at the point is nearly horizontal, though it has a slight dip to the N. The bluff which lies to the north-east of Duncan's house has fossils in it which are most decidedly of a character agreeing with the Akuaku beds. The south bluff also contains fossils of a like character, but in it they are not so plentiful as they are in the north-east bluff.

24th April.—To-day I went south as far as the white bluff, at which point fossils in the cuttings of the road are found. I was curious to know what the white bluff, which forms the point at that place, really was. I crossed the hill at Duncan's, and found Big Hill (Anauri) to be about 850 feet in height. On or near the summit of this hill is the white sandstone, 450 feet above the sea in Duncan's section; but here it dips in the very opposite direction to that in which it dips at Duncan's, with an angle of 25°. The mass of the hill seems to me to consist of blue sandstone which has weathered brown, and which is also clearly stratified; in this respect, at least, these sandstones resemble those of Tawhiti.

On the smaller hills which lie between this and the next sea bluff I could see a bed of sandstone which was of very great thickness, perhaps from 20 to 30 feet, and this reaches the beach just before the track leaves the sandy beach to go through the saddle, and forms a reef of rocks which runs out to sea a distance of from 150 to 200 yards. Next, and overlying this stratum, there follow the fossiliferous beds, which are well exposed in the cuttings of the road. These had in them fossils of a very tender nature, which were, on the whole, more like the fossils in the Akuaku beds than any other fossils to which I could compare them. They were, however, so tender that the want of proper packing material renders their preservation very doubtful. There are some grey-and-white sandstones which directly overlie these beds, and which form the upper beds of the bold bluff to the south (Marau Point). These beds are fully 100 feet in thickness, and dip in the same direction, and the angle at which they dip is no less, being 25°. The lower parts of the bluish-grey stone seem to have in them a number of shells, which have been broken up, but there is nothing in them very distinct, fragments of *Pinna* being found. The purely white stone is destitute of fossils of any kind. These white rocks form the uppermost beds on the hill north, and appear on the beach, still dipping at no less an angle, about 100 yards south of Kaiaua Pa. Here there are lying on the beach great masses which render it difficult to pass at high water. From here these rocks strike inland along a range which has a deep valley on its south side.

TOLAGO BAY, 28th April, 1874.

I have already given you a description as far as Kaiaua, and therefore I need not do so again here. At Kopawi I found that the beds still had a southerly dip, and that the material of which they were composed was a bluish-grey and white sandstone; they were also nearly horizontal, and the darker coloured rocks, which were interbedded with grey crumbling sandy beds, underlie the white and softer sandstones. Now, either this must be a third set of these sandstones, or else it must have been thrown up by a fault; but which of these two theories I should adopt I could not very well decide, and therefore preferred to leave the question an open one.

From here, early the next morning (*i.e.*, the 28th), I took the track along the swamp, and arrived at Tolago Bay in time for breakfast. The cliffs on the north side of Tolago Bay dip to the N., and have in them a few not very distinct shells, such as fan corals, tubes, and also a *Dentalium*, which latter was very similar to the larger one I found at Akuaku. The light-banded rocks which streak the cliffs and are seen in the south face of the island off the north head of Tolago Bay turn out not to be sandstones, but calcareous marls, and they may be seen at the point round which the track leads as you leave Tolago Bay to go to the north.

From Kopuni almost up to the north head of Tolago Bay the beds are very nearly horizontal, and it may not be so much wondered at. At all events, from what I saw I am very much inclined to place these beds under the *Ostrea-Pecten* beds, and believe that such an arrangement would stand good. Blue sandstones are seen in the tideway, and these are similar to those at Duncan's. In the river bed, close to the ferry, are sandstones interbedded with crumbling marls, and very similar to the *Leda* beds of Tokomarua, but I was unable to find any fossils in them; their dip was N., and ranged from about 35° on the north side, to vertical on the south side, of their exposure. These might be a part of the tertiary rocks, but I would be much rather inclined to think they are *Leda* beds, and that they might be possibly even older, but I had not any means of deciding this point.

WHANGARA, 30th April, 1874.

On the 29th I walked over the hills to Cook's Cove, so that I might be able both to see the rocks there and also those at the big hill to the south. After following a spur, I was brought to a small bay, and found blue nodular sandstones with the beds of shell grit and shells; and there is here, also, some coarse shell-grit which very closely resembles that of the shell beds near the town of Napier. From these beds I got *Cucullæa*, *Pectunculus*, *Struthiolaria*, and *Ostrea;* also a new shell, rather large in size, which I do not remember having ever seen anywhere before. I succeeded, also, in finding *Dentalium*, and the species of this fossil that I found was the same as the largest form of it that I got at Akuaku. I was also able to procure some fan corals from the same place, as well as from Duncan's. I was not able to see the quartz-grit beds at this spot, but I did see them on the spur further south; and, when I afterwards resumed my journey, I saw that there were huge masses of it which had tumbled down from the hill above and now lying near the track. After considering for a short while the character of the fossils which I procured in this spot, I found myself no longer able to resist the conclusion that the beds are tertiary, and from the south side of the anticline, which appears to have been denuded by the excavation of Tolago Bay, in the very axis of the anticline. The beds at the point at which I observed them strike to the S.W. 70°, and dip about 15° to the S.E; but, in a short time, as you follow them south they become almost horizontal. The face of the cliffs which lie along the sea is streaked by white sandy beds, and between the general strata of these beds I was able to make out beds of brown sandstone, between which came the crumbling sandy clays. I was not able, by any means, to get round the corner as far as the spot at which I was expecting that I should see the beds of grit, but I am perfectly convinced in my own mind that the rocks from which I got the fossils are underlying the beds of grit at this place: I mean to say that the beds of grit exist at the last point opposite to the small island which has the sharp pinnacle in the form of a sugar-loaf, and at the west side of which I observed something which seemed to me to be very similar to a white rock. After I had perfectly satisfied myself on this point, I went back again, and resumed my journey, having taken all care to bring with me any specimens of the various fossils and rocks that I had found. Notwithstanding that the day was a wet one—and for that reason also very unfavourable for getting along such roads as I had to travel over—I continued to push on as far as Priestley's, and on my way I observed that, as the track went down on the south side of the saddle, the brown sandstones which were seen in the cuttings of the roads about there again dipped at an angle of 30° in a north direction, and also that the high bluff which lies on the coast north of the point, at which the track comes down to the beach, was formed of the same rocks. To the south I could see similar rocks, which continued to dip in the same direction for a distance of about three quarters of a mile. I should have remarked before that these rocks in the cuttings of the roads contained tubes, and seemed to me to be the only fossil they did contain; and, although I took the trouble to search for others by examining the sandstone boulders that are in the bed of the creek as you come on to the beach, still I was not able to find any thing more. There are also some tertiary, sandy-looking marls with concretions (which appear to be very similar to the concretions in the *Leda* beds) which seem to have the same strike and dip as the beds mentioned just above, though they are underlying them; but in these, too, I was not able to find any signs even of fossils, and, as their stratification was not at all clear, they may or may not belong to either series.

A little further on to the south, at a spot where there is a flat of some extent behind a sandy beach, I came upon some rocks which crop out of a low bank. As regards their dip, and strike too, these rocks are so clearly at variance with the general strike and dip of the tertiary beds, and besides they also differ so much in their character, as not to leave the slightest doubt in the mind that they belong to older and underlying rocks, between themselves and which there must be an unconformity. They strike to the north and south, and dip to the west, and consist of sandstones which are irregularly laminated, but in many other respects they are not at all unlike the tertiary, inasmuch as they have crumbling shales between them. These rocks continue along the line of the coast as far as the next high bluff, which is on the coast to the south, and which consists of, on the beach, dark marls very slippery in their appearance, and which appear to be alternate with the sandstones.

WHANGARA, 30th April, 1874.

I examined a reef of rocks seen at low water, and found them to consist of green sandstones. They strike north and south, and dip 15° E. The only conclusion I could come to about them was that they belonged to the *Leda* beds, as they contained no fossils. The next rock I saw was at a creek a little north of the Hole in the Wall, and here black marls with *Nummulites* strike in the same, or nearly the same, direction, and contained also fragments of the shells of sea urchins.

I therefore came to the conclusion that there might be an anticline here, but the green sandstones might, for all I could tell to the contrary, belong to the *Inoceramus* beds, though it would be, perhaps, as safe to regard them as *Leda* beds for the present, there being no doubt that the dark marls in the vicinity are such. Thence I passed on to the Hole in the Wall, and found that the grit beds there strike S.W. and N.E. 45°, with a dip to the N.W. of 10°. There are calcareous marls both above and below the grit which forms the roof of the archway. I brought specimens, but did not get any fossils, though in coming up I found here plenty of the flat, coiled *Nummulite* so common to, and I venture to say characteristic of, the *Leda* beds.

Gable End Foreland is a white, close-grained rock, not chalky, but more of the nature of the coarser gritty sandstone, which is also here. There was nothing here which looked like limestone. The higher beds overlie this, and form a little bluff behind the larger one, of a greensandish nature, but decomposed, and having a rusty-red colour. This rock may be seen from further down the beach overlapping the white rock. Here I could find no fossils, but deemed it safe to conclude that it belonged to the *Leda*-marl formation, and I therefore passed on and came to the Old Man's Face, where the strike is more westerly and the dip equally as high, the rock being somewhat similar. Passing round to the reach of the bay of which the Old Man's Face and the neighbouring point form one headland, I found the bluff to the south to be contorted sandstones, striking at right angles to the rocks at the Old Man's Face, or due E. and W., and dipping north. The rocks resembled the sandstones of the chalk-marl series more than any I have seen since I left those beds, and from what I see here I have no doubt they are such. They continue along the coast to the river one mile north of Mr. Wallace's, where curious-looking light-greenish marls are seen.

GISBORNE, 2nd May, 1874.

The hills behind the station at Whangara I found to consist of indurated chalk marls, to all appearance interbedded with gritty greensands. The whole of this presented a much-fissured aspect, and all the cracks therein have since been filled with carbonate of lime in a crystalline condition. These rocks are thus most interesting, and confirm my suspicions as to the age of the bluffs further north. I saw no concretionary boulders, though some small ones have been placed round

Mr. Wallace's house by way of ornament; and the fact of the presence of even these small ones (they having been picked up in the creek near by) goes far to prove their existence. On Whangara Island, and the mainland opposite, I found greensands indurated to the condition almost of green sandstone. These greensands overlie the purer indurated chalk marls, and strike N.N.E. at an angle of 80°, dipping to the south, and forming a bed of almost, if not quite, 100 feet in thickness. The greensand is overlaid by stratified marls, less pure and not so much indurated as those lying beneath, which, as one proceeds further on, are not seen for a good distance; but, though not exposed, yet are there, as was proved at the next bluff, where they appear in the sea cliffs. They are followed by sandstone and dark interbedded marls of great thickness standing at a high angle, which run out as a shoal, and form what the map shows as the Tapua Rocks, and are succeeded again by marls with concretions very similar to those in the Poverty Bay section. Not till the second bay from that south of Whangara, in which McDonald has a shepherd's hut, is there any sign of a change of dip. At this point the dip appears to change, the rocks seen in the mouth of the river at Gisborne forming the uppermost bed in the syncline. The succession also repeats itself quite conformably on the south side of the syncline, till one passes the last big bluff before crossing the saddle which avoids the Makarori Rocks; and at this point a fault or disturbance of some kind seems to me to have thrown the rocks out of place, as here they strike in all sorts of directions—from almost vertical one mile north of the point, to almost horizontal at the point. On the top of the bluff at the back of the Tapua Rocks I saw the white sand formation of Gisborne in horizontal strata, of a thickness of from 25 to 30 feet, which gave to this hill, as seen from the south, a tabular aspect; and in the valley of the creek which falls into the next bay south it seems to be present also, but on going further south I saw no signs of it, though I keep a pretty sharp look out. Thus it would seem to me to follow up the valley of Waimata, and to strike in a due line to the point where I last saw it, and, though it seems to rise higher than many of the seaward hills, as far as I could judge it follows a straight course to the point mentioned.

4th May, 1874.

As the weather to-day began gradually to improve, I went out in the afternoon in search of the coal which is supposed to be on Bryant's property, and I did, indeed, succeed in finding it out, if such is what it may be called. It certainly does seem to me to be very much inferior to the peaty lignite that is near McDonald's, only that it is harder, which is caused by the fact that there is a greater quantity of impurities in it and also in the beds which overlie. As far as I was able to make out from my examination of them, they belong to the formation of the white sandstone, of which one is able to see the low terraces in the immediate neighbourhood. But as to its relation, it cannot be made out at all clearly, except that it ought to be placed at the base of that formation, and occupy a very nearly horizontal position, as is indicated by the distance it crops out along the edge of the creek. Below it, and coming in a direct line with the strike of the *Leda* beds of the adjoining spur, there are beds which I should infer, from their appearance, to be very similar. Moreover, it is worthy of notice that the recent shell beds of the river bank extend as far as this, cropping out in the banks of the creek. I bring with me a specimen of this lignite, and, so far, have done with it for the present. I was not able, however, to resist the temptation of once again making a search in the curious tufaceous rock of which the mass of this spur is formed, and from which I was able on a former occasion to procure a few obscure specimens of the *Pecten zitelli.* This time I had still greater success than on the previous occasion, and I have great pleasure in being able to report to you that I found the presence of the Cobden *zitelli* with nine ribs, eleven being, if I recollect rightly, the proper number of ribs. I was lucky enough to procure a great number of very fine specimens, some of them corals, and amongst others what I took to be, as far as I could judge, a small but highly-ornamental portion of the *Struthiolaria senex.* But worthy of mention above all the rest, I found the *Conus* of the Mokihinui series, and the shell with the short, flat spire almost like *Planorbus.* This specimen is about 1¾ inches in length, and its breadth over the flat top of the spire is about 1 inch.

ORMOND, 6th May, 1874.

Yesterday I made a further collection of a few more specimens from the *Pecten zitelli* beds at Gisborne, and in the afternoon, having finished all I had to do there, I came on by coach to this place. On the following day I made examination of the hills to the north-east, as well as to the east, of the township. The chief object I had in view was to find out the limestone if I could, as the position of this had been indicated by you in the map which you left with me. It turned out that the position you had marked for it was correct. It occupies an almost horizontal position, and dips gently to the N.E.; in character it is calcareous sandstone, with an inter-mixture of a great deal of greensand —it would, in fact, be quite possible to get specimens which would show the whole progression from almost a pure greensand to a limestone, which is also, comparatively speaking, pure. It is both underlaid and overlaid by a brown sandstone of a very similar character to that which is seen a little way further to the north, as, for instance, at Tokomarua and at Akuaku. It (*i.e.*, the greensand and limestone) contains, as I found, an abundance of fossils. In character these fossils seem to me to approach nearer to those which I found in the limestone at Hawke Bay, as seen close to the town of Napier, than to any other, though there are also present many rocks which are of frequent occurrence in the rocks at Akuaku. I was not able to find any *Cucullæa* or *Pectunculus* here, and it is also worthy of notice that there are not any univalves whatever, except here and there a *Planorbus.* The fossil forms which do occur here are the *Pecten triphookii*, with two species of oysters, of which both are common to the rocks of Napier; but, on the other hand, though all these shells were there which are also very common in other beds, I found also the *Cardium*-like shell which I described, when I found it at Cook's Cove, as being new to me. There were also the ringed *Dosinia*-like shells which are to be found in Tawhiti, together with some few others. I also found the *Mythius* shell, which is another common form in the rocks of Napier.

At the first glance the greensand beds reminded me very much of the *Ostrea-Pecten* beds of Akuaku and also at Duncan's, but it is perhaps rash thus to assert, in a positive manner, anything which is only a guess. I almost despair now of being able to run this section down to the *zitelli* beds, though I should very much like to do so. Its higher beds I am fully expecting to see on my way to the oil springs, and it is my intention to turn my steps in that direction to-morrow morning. Very similar ranges and rocks are to be found in the low ranges to the N.W. of the river; and a hill, which one can plainly see in the distance, has a bold scarp on its northern face, and is evidently composed of limestone. I should judge that the country to the north would show only the lower beds, while the country between this and the oil springs would show the higher beds. I shall endeavour to make out, in these two localities, how it is that this limestone is related to the rocks which are shown there.

On the hills which lie to the north-east of Ormond, I have not as yet been able to see anywhere the red sandstone with shells which is marked down in your section, but I have no doubt that I shall be able to find it on the other side of the river, where it most probably comes in.

10th May, 1874.

On the 7th instant I left Ormond for the oil springs, and, having regard to the position of the limestone on the ranges behind Ormond, found that the lower beds were exposed in the hills behind Scott's station, whilst the country between Ormond and the crossing of the river exposes the overlying beds of a very similar character. A short distance above Ormond these beds form a syncline, but I could not see the limestone repeated here; it might, however, easily have escaped my notice. I followed up the bed of the river all the way to Cuff's, and saw nothing but blue clays the whole distance. On my return, however, I observed the white sand within two and a half miles of Cuff's, on the low hills that bound the terraces. I did not search the blue clays underlying the white sands, but the fair presumption is, as I shall show, that they are tertiary beds.

In the meantime I pushed on, and entering the creek which leads to the oil springs, hurried on, as it was getting late. Here I stayed for the night, and on the following morning went to the top of the hill behind the springs to see where the limestone cliffs were of which you spoke. I could not see anything in a north-east direction at all resembling the section you gave me; the only thing I saw similar to it being a bluff mountain due north of the springs. This, however, lay a distance of four or five miles off, and a low, rugged range intervening rendered any approach to it a work of some difficulty. Viewing it from a distance, I should say that the rocks composing it are tertiary, and with what reason I say this shall afterwards appear. A rugged and broken country lay to the east, which I did not deem it advisable to penetrate, considering the season and the provision I had made for this journey. I did not see that I could do much here after having a look at the wells.

The oil springs appear to flow from chalk marls of a very pure character, more so than in any other locality where these rocks are seen. They crop out on the hill along the track, and are connected with party-coloured clays, which show well just where the track leaves the creek.

A little further down concretionary boulders are occasionally, but not numerously, found. Flaky chalks succeed, in which the ascertained strike is N.E. and S.W. at an angle of 55°, with a dip to the S.E. at an angle of 55°. The occurrence of a conglomerate consisting of very coarse and often angular pieces, and containing fossils of a tertiary character (including *Ostrea*, a small *Pecten*, *Turritella*, *Voluta*, *Dentalium*, *Waldheimia*, corals, and others), puzzled me not a little. I could not here find a *Pecten zitelli*, but I did find a small *Pecten* very like *P. hectori*, which might be mistaken for it at a rough glance. As these were found up the creek some distance higher than the junction of the newer beds at its mouth, I could not account for them here except by supposing that some outliers existed amongst the chalk hill. A brown sandstone having *Pectunculus*—the same as those found on the north side of Tawhiti, Tokomarua—puzzled me not a little, as I had not seen any such rock as I came up the creek. Near the junction of the chalk marls with the younger dark-coloured rocks I found masses of non-fossiliferous greensands, resembling the Awanui greensands. The chalks become less pure, not so flaky, and darker in colour, before the junction is reached; and there dark-coloured sandy clays succeed, bedded with brown sandstone bands, but without fossils, striking nearly E. and W., and dipping S. at an equal angle of 55° with the chalk marls, which continue to the mouth of the creek, a distance of about a mile. In the creek, where the chalks are exposed, are found boulders of the hard trap rock, and this was also found on the beach at the mouth of the Waiapu and in the big creek cutting the tertiary range in the direction of the conical peak behind the hot springs. In this last-mentioned place it occurs in considerable quantities. Here, in some specimens, it was open and porous; sometimes these cavities were filled with round pellets of white felspar, in others of a dark felspar; in all cases, however, crystalline, and presenting a stratified appearance like gneiss. I looked over this creek carefully for any appearance of the black shale of Awanui, but saw none, which somewhat dashed my hopes of being able to point to the probable source of the oil, which I supposed this shale to be.

I returned once more to the top of the hill behind the oil springs, and I should judge, from the appearance of the hills, that the chalky rocks run out to much greater width than at the oil springs, in the direction of Tolago Bay, and might continue on till their near approach to the Uawa River, where, first, the *Leda* marls, and then the tertiary rocks, mantle over them, the last evidence of such being the highly-inclined *Leda* marls at the ferry.

11th May, 1874.

On the 9th instant I saw in the river bed at Cuff's station many fossiliferous boulders containing, besides those described in the creek leading to the oil springs, *Natica*, *Inoceramus*, and sharks' teeth, together with great masses of the trap rock already described. To find these rocks and fossils in the bed rock, I went up the westerly branch of the river, and, about one and a quarter miles above Cuff's, found the dark, dirty, fossiliferous rock and conglomerate having the fossils described underlaid by the dark, sandy clays seen in the cliffs at the junction of the two rivers, so that this bed must overlie any seen in the creek going up to the oil springs. Here was a total absence of the crystalline rocks, and the shingle derived from the chalk marls was nearly absent also, so that it was evident this was the wrong branch of the river for my purpose. I therefore returned to the main (or north) branch of the river, and followed it. Here I found that the crystalline rocks increased in size as well as in frequency, till suddenly the highly-inclined younger rocks ceased and chalk marls made their appearance, and continued for a distance of about half a mile, and from here they were again followed by tertiary rocks, at first highly-inclined and dipping away to the north, but shortly becoming almost horizontal.

Almost as soon as the chalk marls are passed the crystalline rocks nearly disappear from the river bed. This clearly points to their source as being in the chalk-marl series, though I have never yet been able to find them *in situ*. On the north side of the chalk marls, and in close connection with them, great masses of greensand are found in the river bed, and concretionary boulders, the source of the *Inoceramus*, are also seen near this place in the bed of the river. Down this river also come many specimens of every kind of fossil of which I have made mention in the locality. The tertiary rocks, which Mr. Cuff says overlie and stretch away up the river a distance of about ten miles, no doubt correspond to the Akuaku and Tawhiti series. This is a very reasonable supposition, and, if correct, it follows that the high, bluff range north of the oil springs is composed of the greensand *Ostrea-Pecten* beds of the range behind Duncan's; and from what I was able to judge of this part of the country, I should say it continues between Duncan's and this point. These younger beds, forming horizontal beds on the east bank of the river, occupy the hill tops overlooking the creek which leads to the oil springs, and this, I may safely say, is the source of the fossils which are higher up than these rocks reach in the bed of the creek.

WELLINGTON, 18th May, 1874.

From the 10th to the 12th instant I was detained at Ormond, owing to the state of the weather. On the 13th I again examined the section on the north side of Poverty Bay, going along as far as McDonald's, and on passing on to the island at the heads I found there what appear to be the same beds as those seen at the next point further north. These seem to be parted from the sandstone weathering out large boulders by what I regarded as a fault extending from this point to a point upon the coast a little way to the north of the Makarori Rocks. It would therefore, in all probability, be very difficult to determine for certain what is the horizon of this part of the section. The strike of these beds on the east corner of the island is S.E. about 43°, and they dip at an angle of from 10° to 15°. The rock itself contains blue sandstones and also some fragments of plants, which however, not being very well preserved, were hardly recognizable when I came to examine the section a little further north, at Tuahine Point. On no occasion was I able to find any fossil shells. On the north-east corner of the island, which adjoins the boulder beach and which is perfectly dry at low water, there is some sandstone in the form of boulders, very like those on the mainland, which lies just opposite, so that the anticline itself is contained in the soft, sandy beds which underlie the grey sandstone weathering large brown boulders.

With a view to fixing this boulder bed, and also, if it should seem feasible, to show its relationship with the rocks of a similar character in the section between Tuparoa and Roporua, I paid some attention to it, expecting to find some fragments of the large *Inoceramus*, which, however, I was unable to do. I noticed the absence here of cone-in-cone, which is so characteristic of the sandstone boulders in the Roporua section, and found nothing except a few *Nummulites* and fragments of coral, and what seemed to me to be the cast of a *Dentalium*. Directly after you pass this point, to follow the succession upwards, the section is obscured for fully a quarter of a mile by younger beds; yet, if we have regard to a profusion of material that lies on the beach, we should have but very little difficulty in coming to the conclusion that the beds which are so obscured are just similar to the sandstones that underlie the chalk marls at Awanui, in the section between that place and the mouth of the Waiapu. In the last mentioned section there are, as you are well aware, green sandstones, with pebble beds, which are to be found also at Awatere, Roporua, and Tuparoa as well. Taking this for granted, I next pass on to the large slips on the coast line, where, near an old fence, are seen soft blue sandstones, which underlie the chalk marls being next in sequence to them. These sandstones are but very partially exposed, yet there is very little doubt as to their being at the place, but, as not apparently containing any fossils, a passing mention of their position may suffice. They might occupy 150 yards of the coast line, and the distance from their upper boundary to the island I estimate at half a mile; and all the rock within such distance standing at a very high angle (if we except themselves), from 60° to 80°, it is evident that within this distance is contained a considerable thickness of strata, probably not far short of 2000 feet.

From the lower boundary of the chalk marls I paced within rock of this character 650 paces, and I might estimate their angle at about 40°. Next come sandstones, but I should have mentioned that boulders, apparently from the chalk marls, contain *Inoceramus*, and some other forms, besides masses of cone-in-cone, but the fossils require working out before much can be said about them.

In this part of the section you could not fail to observe one large brown and perfectly spherical concretion, lying a little under high water mark, with many others of less perfect form. Much material from this part of the section has been swept inwards along the beach towards Gisborne, where fine samples of cone-in-cone and small boulders, with *Inoceramus* fragments, may be found. Disregarding the younger uncomformable beds, which the slips have here brought almost to the water's edge, the sandstones succeeding the chalk marls occupy a distance of 850 paces, or from the disappearance of the chalks opposite the low saddle, with much slippery ground S.E. of the high hill, capped by the brown sands of the young tertiary beds, to what I shall term Captain Hutton's fault, where a small creek falls into the bay. Perhaps I should have carried this division further, or to the underside of the large flinty boulders, which, by about seventy-five paces of a more marly character, part the boulder beds from the sandstone proper. Of the fault just mentioned, a very little observation shows it, though of some extent, to be merely a slip from the hill behind; in proof of which the section may be followed at low water, when it shows no trace of any alteration of strike or dip, although at one point in the so-called faulted part the beds are lying horizontal. Some parts of these sandstones contain quantities of broken shells, *Nummulites*, *Dentalium*, *Leda*, and some *Fusiform* shells, which I cannot name. This portion of the section is the most difficult to estimate, as the winding shore line prevents its being done, except with some trouble, by pacing at right angles to the strike of the beds, and something must be deducted from the paces on that account. One hundred paces of boulders next follow; of these, however, I did not take any particular notice, as I found in them nothing but tubes.

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